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AGE CHANGES AND VARIABILITY IN GIBBONS

A MORPHOLOGICAL STUDY ON A POPULATION SAMPLE OF A MAN-LIKE APE

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INTRODUCTION

Progress in our understanding of the nature of man depends to a large extent upon a thorough knowledge of man's nearest animal relations — the man-like apes. The latter are modified, diverging, evolutionary experiments with the same ancestral stock which has also produced man, hence the study of anthropoid apes is bound to reveal many of nature's means and limitations in the creation of mankind. The biological investigation of man has been carried to such detail, has been undertaken from such a vast variety of points of view and has been facilitated by such abundance of material and observations, that our present knowledge of man's simian cousins is by comparison extremely scanty and quite inadequate for the urgent purposes of throwing new light on man's past and recent conditions. It is as yet impossible to state fully in what respects and to what degree man's growth and development differ from or agree with the age changes in all the man-like apes. That this is a fundamental and promising problem is evident if it is considered that, since all specific characters are merely the end results of inherited ontogenetic processes, evolutionary innovations are primarily alterations in the detailed conditions of growth. When we have learned which of the latter are the same in man and the apes and which others are peculiar to man, we will be nearer to an ultimate understanding of the causative factors in human evolution. It is commonly maintained that individual variations of a hereditary nature represent stepping stones for phylogenetic progress. With this highly plausible assumption it seems most desirable to study the problem whether or not all the well-known variations in man are more common and marked than are individual variations in man's nearest animal relations. Here again the final answer must wait for many additional data. That our knowledge of the anthropoid apes can not yet compare with the available information regarding man, is largely due to the fact that, with relatively few exceptions, studies on apes have not yet reached that statistical phase of science which has been so fruitful in human biology. This, in turn, is due to the lack of adequate material or the difficulties in collecting sufficient data bearing upon problems, such as the examples mentioned above. Anthropoid material in our museums consists chiefly of skins and skeletons of mostly adult specimens (Krogman and Schultz, '38) and of very little else. More and different material and a vast and varied amount of new observations are required before ape biology can approach modern human biology and physical anthropology in comprehensiveness and depth.

Of the few types of recent anthropoid apes only the gibbon survives in such large numbers and such a wide territory that it is possible and fully justifiable to collect series of specimens adequate for at least some statistical investigations, requiring homogeneity of material. In the countries of south-eastern Asia gibbons can still be found in countless thousands. In northern Siam, where most of the material for the present study has been collected, gibbons are the most common mammals in evidence and there can be little doubt that they will continue to thrive as long as their forest home remains essentially unchanged.

As indicated in the title of this paper, a "population sample" of the gibbon has been obtained for the purpose of investigating chiefly the age changes from fetal life to senescence and the degrees of variability of different structures of this man-like ape. In addition this unselected material has made it possible to study the kind and frequency of developmental abnormalities as well as of some pathological features, as they occur under natural conditions in these wild animals. The main series used in this investigation has been collected in one locality. A second and larger series (including the first) is composed of specimens from one limited district. For some purposes, finally, gibbons from several countries and of different species have been combined in one large series which forms the basis for further statistical analysis and for comparisons with other primate genera, as will be described in more detail later.

This study represents one of the results of the Asiatic Primate Expedition of 1937 which had been organized by Mr. H. J. Coolidge, Jr. The Carnegie Institution of Washington had generously contributed a grant toward the author's expenses on this expedition, which had as its foremost purpose the collection and study of gibbons in their native habitat. The findings appertaining to the behavior and social relations in gibbons have been recorded in a valuable monograph by Carpenter ('40). Many of the specimens, studied morphologically by the writer, had first been under observation in the field by Carpenter and figure in his report. The gibbon material from this expedition has been used before in connection with some other studies of the writer.[1] A special report on the hair coloration of these gibbons is in preparation (Allen,

[1] These special studies, containing data on these gibbons, are the following: Relative lengths of the regions of the spinal column ('38 b); Relative weight of the testes ('38 c); Diseases and healed fractures ('39); Size of the orbit and of the eye ('40 a); Relative size of the cranial capacity ('41 b). It is mentioned here also that the female reproductive tracts of these gibbons, which had been preserved by the writer, formed the basis of a paper by Dempsey ('40).

Coolidge, Greenway, and Peters, '40, p. 148). Several accounts of the activities of the Asiatic Primate Expedition have already been published by Coolidge ('40), Carpenter ('40) and the writer ('38 a). At this place the author can merely express again his sincere gratitude to all the numerous friends at home and in Asia who have helped in manifold and generous ways toward the success of this expedition.

MATERIAL

The Asiatic Primate Expedition established its first headquarters in the Siamese city of Chiengmai which lies 375 miles north of Bangkok and about 70 miles east of the Burmese border. The chief series of gibbons was collected near the expedition's camp on Doi Angka, the highest mountain (8448 feet) of Siam, about 35 miles west of Chiengmai. These gibbons were shot by members of the expedition and by natives, living in the neighborhood of camp, many of whom used crossbows with small arrows in hunting. Upon arrival in camp every one of the gibbons was immediately measured by the author according to the methods fully described in a previous paper (Schultz, '29). The specimens were weighed fresh and closely examined for possible abnormalities which were photographed or sketched. The bodies were then skinned and eviscerated. Some organs, parasites, etc. were preserved, whereupon the skeletons were prepared for drying in the field and later, thorough cleaning at home. All skeletons of infants were first left for 24 hours in neutralized formalin for fixation of cartilaginous parts. A total of 107 gibbons (+ 2 fetuses) were collected at this camp. This material will hereafter be referred to as the Angka series and figures as such chiefly in the discussion of body proportions and of growth. This Angka series contains 1 small fetus (sitting height = 98 mm.), 1 larger fetus (sitting height = 160 mm.), 8 infants, 2 specimens classified as "juvenile I" and 17 as "juvenile II", and 80 adults of which 37 are female and 43 male. Even though this material has not been selected in any way and represents a typical population sample, it contains too few young animals for the purpose of studying growth changes in body proportions. For this reason the following 4 specimens have been added to the Angka series, increasing it to a total of 113, as used in the chapter on age changes in proportions: 1, a fetus (sitting height = 109 mm.) collected together with the skeleton of the mother animal by Mr. H. G. Deignan in 1935 at the identical locality of the present Angka material [2]; 2, a "newborn" (sitting height = 173 mm.), mea

[2] This fetus and the skeleton (no. 260590) were received as a loan from the U. S. National Museum with the kind permission of Mr. G. S. Miller, Jr.

ured by the author many years ago in the anatomical collection of the university of Zurich; 3 and 4, 2 small infants, generously given to the writer by Mr. F. N. Chasen, director of the Raffles Museum in Singapore. The last 3 specimens are known to come from Siam and are certainly of the same species as the gibbons from Doi Angka. For the analysis of growth changes in body proportions the 2 smaller fetuses represent what in later tables is designated as the "fetal stage" and the nearly full-term fetus together with the newborn specimen figure in these tables as the "newborn stage".

After the departure of the Asiatic Primate Expedition from Doi Angka one of the Siamese assistants, who had been employed and trained by the expedition, decided to collect a series of gibbon skeletons in the district surrounding Chiengmai within a radius of about 35 miles. This additional material was eventually purchased privately by Dr. S. L. Washburn and the writer. It consisted of complete, dried skeletons of known sex and locality. The writer acquired 44 of these skeletons and Dr. Washburn 38. The latter specimens had been very generously lent to the writer by Dr. Washburn. Two further gibbon skeletons from the district of Chiengmai were later purchased by the author from other Siamese collectors. At his camp at Chieng Dao, about 35 miles north of Chiengmai, Dr. C. R. Carpenter had collected 39 gibbon skeletons of which 32 went to the Museum of Comparative Zoology, 5 to the Peabody Museum of Harvard University, and the remaining 2 were very generously donated to the author. Dr. Carpenter's material also was lent to the writer with the permission of Dr. T. Barbour and Dr. E. A. Hooton. Finally, 3 more specimens (now in the Museum of Comp. Zoology) were obtained by the Asiatic Primate Expedition in the neighborhood of Chiengmai and could be studied by the author. In addition there was available the above mentioned skeleton from Doi Angka, collected by Mr. Deignan, and, principally, the series of 106 skeletons[3] from the gibbons which had first been measured in the flesh, comprising the Angka series. This last series, the property of the Museum of Comparative Zoology of Harvard University, had also been sent as a loan to the writer's laboratory. The total of all these gibbon skeletons from the district of Chiengmai is 233. This unique material will hereafter be referred to as the Chiengmai series. It may be specially mentioned here that, with the exception of Dr. Washburn's specimens, all this material came to the author's laboratory in the "roughed-out and dried" state in which it had left the

[3] One of the smallest infants of the Angka series had been embalmed and was not made into a skeleton.

field, each skeleton wrapped in cheesecloth and securely tied and labelled, and that the final cleaning was undertaken by the writer himself with the utmost care to prevent losing or mixing of skeletal parts or of teeth.

While in British North Borneo with the Asiatic Primate Expedition the writer had the opportunity to measure 8 gibbons (+ 1 fetus). Here a total of 13 gibbon skeletons was obtained which the writer had as a loan from the Museum of Comparative Zoology at Harvard, again with the generous permission of Dr. T. Barbour. After his return from Borneo the author received 5 additional, more or less complete gibbon skeletons through the kindness of Mr. H. G. Keith, Chief Conservator of Forests in British North Borneo. Another series of gibbon skeletons was placed at the disposal of the writer by Mr. W. H. Osgood, who had collected these 11 specimens in one locality in Assam, French Indo-China. In addition it has been possible to study the skeletons of 15 other gibbons of various species. One of these was obtained by the Asiatic Primate Expedition in Sumatra and was kindly lent to the author by the Museum of Comparative Zoology and the remaining 14 are from the writer's private collection. Nine of the latter had very generously been contributed by Mr. F. N. Chasen, and the others had been purchased by the writer in former years. With these 44 additional gibbon skeletons and the 233 of the Chiengmai series a General series I of 277 skeletons is formed, useful for various broad comparisons in representing the genus Hylobates. The total numbers of specimens in the three series are slightly reduced in some tabulations, whenever a particular structure in one or another specimen is unsuited for inclusion in the series on account of extensive breakage, pathological changes, etc.

The Angka and Chiengmai series consist entirely of gibbons belonging to the species Hylobates lar (Linnaeus). The material from North Borneo belongs to the species Hylobates moloch (Audebert)[4] and that from Indo-China to the species Hylobates gabrielli (Thomas). The species names of the additional specimens in the General series I, as well as those of the material mentioned below, are of interest in connection with only few features to be discussed and will appear in later tables.

During a visit to Singapore in 1937 the author had the opportunity to examine the very extensive collection of primate skulls at the Raffles

[4] This determination is in accordance with the note by Cabrera ('30). H. cinereus and H. leuciscus are synonyms for this species, widely used in other publications, but the name H. moloch has priority claims. The subspecies occurring in British North Borneo is H. moloch funereus.

Museum, particularly the splendid series of 124 gibbon skulls. The writer is much indebted to the director of the Raffles Museum, Mr. F. N. Chasen, for permission to study this material and for many courtesies which greatly facilitated the work. In the tabulations relating to cranial indices and to the conditions of the dentition use was made also of 19 gibbon skulls from the author's private collection which have not been included in the General series I. Data on still further gibbon material figure in a few tables of this study; these have been used before in connection with three former publications by the author ('33 a, '35, '37 a) in which the origin of the material has already been noted. All these specimens, together with those of the General series I, form a General series II, used mostly in the study of the skull and teeth.

Since this investigation deals extensively with age changes, the various age groups into which the material has been divided are defined here:

Infants = specimens with incomplete to complete deciduous dentition, but without any permanent teeth.

Juveniles I = specimens with complete deciduous dentition and with one to four permanent first molars. Since in gibbons one or more of the permanent middle incisors occasionally erupt before all permanent first molars have appeared, such specimens have been included in the juvenile I series.

Juveniles II = specimens with more advanced stages of dental eruption than in juveniles I, but without full eruption of the last permanent teeth.

Adults = specimens with fully erupted permanent dentition.

Seniles = specimens with very marked to extreme degree of dental attrition and with all main cranial sutures obliterated. Senile specimens have not been segregated, except for analyses showing definite changes due to old age. Not all the specimens in this age class are really senile in the proper sense of the term, but all are undoubtedly older than the remainder of the material studied.

The data in table 1 show the age and sex distribution in these series of wild gibbons of known sex, in all of which age was determined according to uniformly applied criteria. Specimens of pre-adult age (infants + juveniles) constitute in all three series 24 to 25% of the total of all specimens and old individuals form anywhere from 15 to 19% of the population. From 56 to 60% of all specimens are adults in the prime of life. The composition by age of human populations differs considerably from that in gibbon populations. According to Pearl

('30), approximately half of all individuals in human populations are on a general average between the ages of 15 and 49 years, slightly more than one third are below 15 years of age, and the remaining 15 to 16% of the population are above 50 years old. Since adulthood in man begins roughly at the age of 20 years, the percentage of pre-adult individuals must be at least 40, or much higher than in the gibbon, and the percentage of adults must consequently be less than 50, i. e., significantly below the corresponding percentage in gibbons. The "senile" gibbons show approximately the same dental and cranial age characters as human beings above 50 years. It is surprising to find that

TABLE 1

*Age and sex distribution in gibbon series. The upper row of figures for each series shows the absolute numbers of the sexes within the age group and the lower row of figures shows the number of specimens within the age group in percentage of the total of all specimens in the series. * = total increased by 11 skulls, chiefly from Raffles Museum; ** = series used in study of dentitions, including material listed by Schultz ('35).*

HYLOBATES		INFANTS		JUVENILES		ADULTS WITHOUT SENILES		SENILES	
		♀	♂	♀	♂	♀	♂	♀	♂
Angka series Total = 107	abs.	4	4	11	8	27	33	10	10
	%	7		18		56		19	
Chiengmai series Total = 244 *	abs.	7	7	23	23	68	78	19	19
	%	6		19		60		15	
General series II Total = 579 **	abs.	8	14	57	61	155	180	56	48
	%	4		20		58		18	

the former survive with slightly higher frequency than the latter. It may be stated here that, based upon his field experience, the writer feels confident that the composition of the Angka and Chiengmai series is typical of a wild gibbon population and that the conditions of collecting did not involve any noteworthy selection among the different ages or the two sexes. The arguments in support of this claim are too lengthy to include here. Many Field observations concerned with this problem can be found in the excellent and detailed report by Carpenter ('40).

The sex distribution in the gibbon material studied is shown in table 1. From these data it appears that there is an excess of males. The

sex ratio in the largest series equals 91 females for each 100 males. It remains here to record some observations bearing upon fertility in gibbons. In the Angka series 5 out of 37 adult females were pregnant, 3 with small embryos and 2 with fetuses. That only 13.5% of these females were pregnant indicates a rather low fertility. Of 14 adult female macaques (Macaca irus), collected in Borneo, 7 (=50%) were pregnant, but of 15 adult female proboscis monkeys, also obtained by the Asiatic Primate Expedition, only 2 (=13%) were pregnant. The same expedition, furthermore, collected in Borneo 27 adult female Pygathrix cristatus and 20 adult female Pygathrix rubicundus; of the former 6 contained embryos or fetuses and of the latter 7. The percentage of pregnancies equals in the first series of langurs 22 and in the second series 35. From the author's field catalogues of four collecting trips to Nicaragua and Panama the following data, bearing on the fertility of platyrrhine primates, are of interest in this connection: In a total of 81 adult female spider monkeys (Ateles geoffroyi) 10 contained embryos or fetuses (=12%); among 22 adult female capuchin monkeys (Cebus capucinus) only 2 were pregnant (=9%); from a series of 84 adult female howler monkeys (Alouatta palliata) 17 embryos and fetuses were obtained (=20%). The percentage frequency of pregnancy varies to a surprising extent among these species of wild primates, namely from only 9 to as much as 50. There is no evidence to assume that in any of these primates in the wild there exists a definite breeding season. The Angka series of gibbons was collected between February 28th and April 22nd of the same year (the pregnant specimens between March 2nd and April 8th). Dr. Carpenter obtained 2 small embryos in May and June (from a total of 13 adult female Hylobates lar) and the late Dr. R. A. Spaeth, who had very generously collected some gibbon material for the author in Siam in May and June of 1925, secured 1 embryo and 4 fetuses. The gibbon fetus, collected on Doi Angka by Mr. Deignan, was obtained in September. Eleven of the 37 adult females of the Angka series had small nursing babies [5] and 5 out of the 10 females, classified as "senile", were most likely too

[5] Nine of these were actually collected with their mothers and the remaining 2 were seen, but lost. All these 11 mother animals had very large mammary glands with a copious supply of milk in striking contrast to the other adult females. The mammary glands of nursing gibbon mothers have been seen after removal of the skin to cover in some instances the entire front of the thorax from just beneath the clavicles to the last pair of sternal ribs and from the midline to the axillae.

old to conceive.[6] Thus there are only 16 adult females neither pregnant nor nursing, yet in the prime of life. That the gibbon of Siam has no breeding season seems amply demonstrated by the facts that embryos and fetuses could be obtained in all the months of collecting and at the same time infants and juveniles of practically all stages of development could be secured.

In this chapter on material it remains to be mentioned that, for the purpose of comparisons, the following additional and not previously published series have been used: 25 wild, adult, male spider monkeys (Ateles geoffroyi), collected by the author in Chiriqui, Panama; 10 wild, adult male and 5 fetal macaques (Macaca irus) from British North Borneo; 10 adult male and 14 fetal American Negroes, unclaimed bodies of the Anatomy Department of the Johns Hopkins Medical School. All this material was measured fresh and by strictly uniform methods by the writer himself, hence the data obtained are perfectly suitable for comparisons with the measurements on gibbons.

Frequently used abbreviations are the following: H. = Hylobates; A. P. E. = Asiatic Primate Expedition; A. S. and figure = catalogue number of author's private collection; R. M. = Raffles Museum. The illustrations for this paper have all been prepared by the author and are drawn directly from actual specimens to show the essential features to be discussed.

GROWTH IN GENERAL

Our knowledge of growth in absolute size of the gibbon is still very fragmentary, largely because we have extremely few observations appertaining to specimens of actually known age or to changes occurring during known age intervals. Thus, we can not even state with certainty the duration of the pre- and post-natal growth periods in the gibbon. Ogilvie ('23) records that in the case of a captive Hylobates lar the time between observed copulation and birth equalled 9 months in the first pregnancy, but only 7 months in the second pregnancy. Evidently there is need for further observations.

[6] These 5 specimens had extremely worn dentitions, all sutures obliterated, very little mammary gland tissue, and thin, pendulous nipples from 24 to 36 mm. long. In nursing females the nipples can be even longer (up to 53 mm.), but they are always much thicker. It is a curious fact that in the great majority of the cases the right nipple is considerably longer than the left. It is also noteworthy that of the remaining 5 females, classified as "senile", 2 were pregnant and 3 had nursing babies. On the other hand, all females showing no, or very slight wear of the teeth had extremely small mammary glands, mere button-like nipples, and were neither pregnant nor nursing any babies. It seems, therefore, that female gibbons may not become fertile until some time after they have attained adulthood and that they differ in this respect from orang-utans (Schultz, '41 a) and macaques (Hartman, '32), but resemble the proboscis monkey (Schultz, '42 a).

Through the courtesy of Prof. John Fulton the author obtained some unique data, showing the growth in body weight in a healthy, captive gibbon. The growth curve, constructed from these records, is shown in figure 1. The animal was killed in a sacrifice experiment in November 1938 and the skeleton was generously given to the writer. From the condition of this skeleton it is apparent that the animal had reached adulthood only a short time before its death, i.e., its permanent dentition must have become fully erupted less than a year before death.

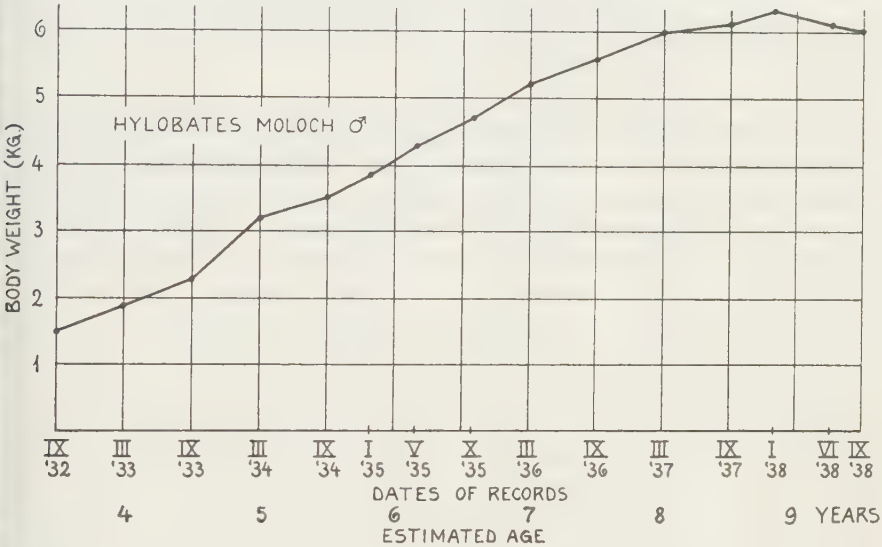

Fig. 1 Growth of body weight in a captive gibbon, according to data supplied by Prof. J. F. Fulton.

Upon arrival in 1932 this gibbon weighed 1.5 kg. This is slightly above the average weight of 1.36 kg. for juvenile I gibbons (5 wild specimens) and below the average weight of 2.15 kg. for the 4 youngest juvenile II specimens. In all the latter the permanent lateral incisors had at least partly erupted in addition to the permanent first molars and central incisors. This particular stage of dental development [7] is reached in macaques early in the fourth year and in chimpanzees in the middle

[7] In a former paper (Schultz, '33) 2 young gibbons of supposedly known age were mentioned, in the older of which all permanent first molars and permanent upper middle incisors had erupted. Unfortunately the author had been misinformed in regard to the age of the latter specimen, which was given as "22 months." Upon consulting the original records, it appears that this gibbon was "received when very young, born by captive mother shortly before arrival." This, naturally, leaves the estimation of the date of birth within wide limits.

of the sixth year (Schultz, '40 b). The gibbon of figure 1 equalled in weight the average of the above mentioned juvenile II specimens in July 1933. With the assumption that at this date the former had the same dental formula as the latter specimens and that this dental stage in the gibbon occurs at an age half-way between the ages of the corresponding stages of dental eruption in macaque and chimpanzee, it may be concluded that the gibbon in figure 1 had an age of 4 years and 4 months in July 1933 and that, hence, it became adult (about January, 1938) at the estimated age of 8 years and 10 months, or between the ages of adulthood in macaques (7 years) and in the great apes (10 to 11 years) (Schultz, '40 b, '42 b).

At birth the gibbon weighs approximately 400 gm. This statement is based upon the single record on a "newborn" Hylobates lar, weighing 411 gm. and most likely about 8 days old (no teeth, great fontanelle wide open, umbilical scar freshly healed). That the average weight at birth in the gibbon must be very close to 400 gm. is indicated also by the fact that all gibbon fetuses close to term, examined by the author, are slightly below 400 gm. in weight and that all gibbon infants with a few first milk teeth weigh somewhat more than 400 gm. The latter material includes a captive-born Hylobates leucogenys, 29 days old, which already had 6 of its milk incisors.

The adult Hylobates lar of the Angka series weigh on an average 5.299 kg. in the females and 5.711 kg. in the males. Individually the body weight varies widely, namely between 3.856 and 6.124 kg. in the females and between 4.082 and 7.258 kg. in the males. It is evident that males tend to be slightly heavier than females. In regard to body length, however, the sex difference favors the latter, though not to a significant degree. In trunk height (suprasternal notch to upper edge of pubic symphysis), e.g., the adult females of the Angka series average 271.1 mm. and the adult males only 268.8 mm. It is certain that a sex difference in size is less pronounced in the gibbon than in the great majority of other primates, including man. Data in support of this conclusion have already been recorded in another paper by the author ('41 a, table 3).

The weight of the newborn in percentage of the average weight of adult females amounts to 7.5 in the gibbon. The corresponding figures for other primates are, as far as could be established, 6.7 in the macaque, 4.6 in the proboscis monkey, 4.1 in the orang-utan, 4.0 in the chimpanzee and 5.5 in man (Schultz, '42 a). The gibbon, therefore, is comparatively large at birth.

AGE CHANGES IN BODY PROPORTIONS

Trunk

The different parts of the body grow frequently at different rates, thus changing the body proportions with age. Table 2 shows the growth changes in the main proportions of the trunk of the gibbon. Some of these changes are also demonstrated by the curves in figure 2.

The chest circumference (at level of sternal insertion of fourth pair of ribs) in percentage of the trunk height (from suprasternale to symphysion) expresses the degree of stoutness of the trunk. In the fetuses the chest girth measures nearly twice as much as the trunk height, but

TABLE 2

Age changes in trunk proportions of Hylobates lar (Angka series). Averages (above) and ranges of variations (omitting decimals, below). For further statistical data on these indices in adults see table 10.

AGE	SPECIMENS	REL. CHEST CIRCUMFER.	REL. SHOULDER BREADTH	REL. HIP BREADTH	CHEST INDEX
Fetuses	2	198.9	62.2	49.0	99.1
		194–204	60–64	48–51	98–100
Newborns	2	175.2	59.2	47.2	101.1
		169–182	57–61	46–48	100–102
Infants	10	132.7	48.9	41.4	114.8
		127–144	42–58	36–45	107–121
Juven. I	2	133.7	49.2	41.4	115.3
		133–135	48–50	41–42	115–116
Juven. II	17	144.5	49.5	41.8	116.6
		131–161	42–56	38–46	109–125
Adults ♀	37	149.1	51.1	43.3	116.5
		133–165	43–59	40–48	108–127
Adults ♂	43	155.8	55.3	43.4	117.8
		143–178	47–65	40–50	110–128

in infants only about one third more than the trunk height. During postinfantile life this proportion increases steadily to adulthood. A continued decrease in this proportion with advance in age is the general rule among primates, at least for females. In males there can occur a late postnatal increase, at least for females. In males there can occur a late postnatal increase, e. g., in the orang-utan (Schultz, '41 a) and the proboscis monkey (Schultz, '42 a). A rise of this index during all of juvenile life in both sexes, which has been found in the gibbon, has

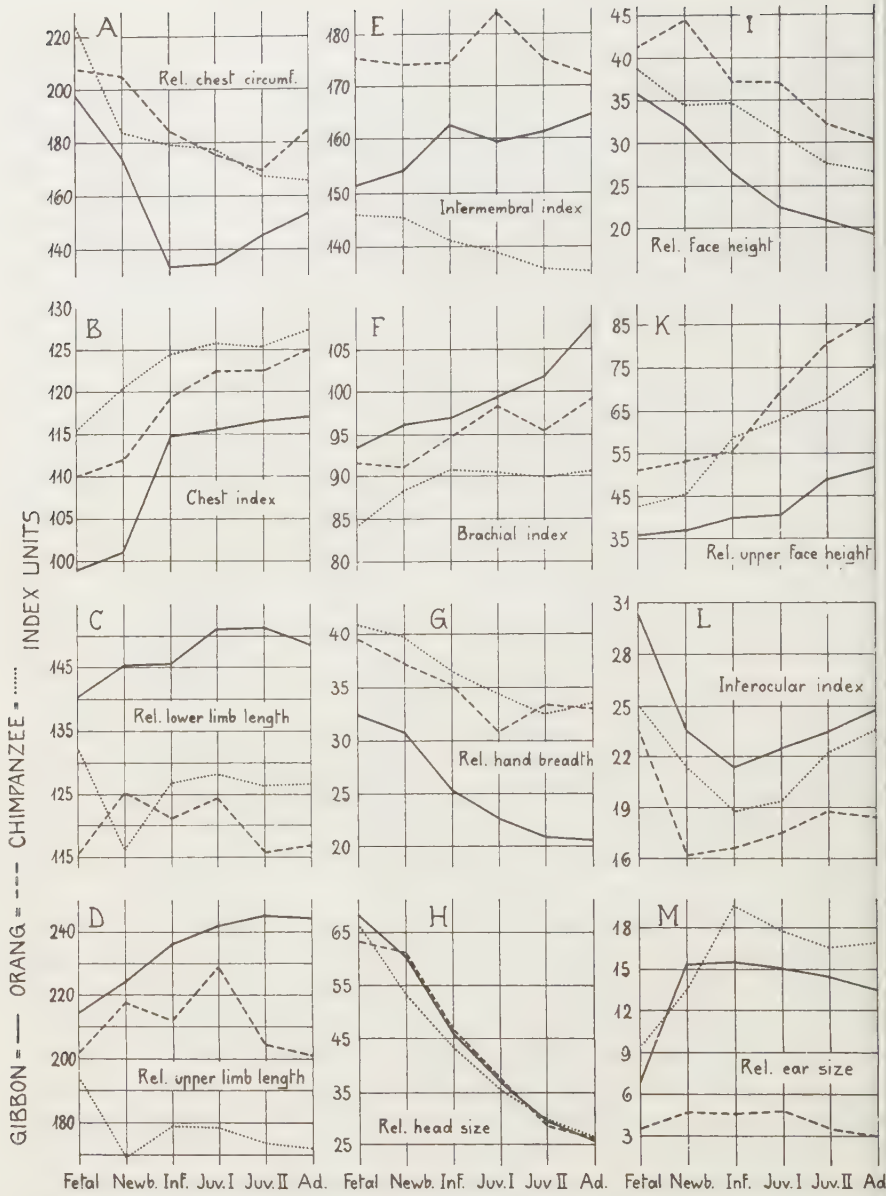

Fig. 2 Curves showing the age changes in some body proportions of gibbons (H. lar, Angka series), orang-utans (Schultz, '41 a) and chimpanzees (Schultz, '40 b). The values for adults are the arithmetic means of the averages for adult females and for adult males.

not yet been encountered in any of the other primates studied by the writer. The secondary sex difference among adults regarding this proportion is not nearly as marked in the gibbon as in many other primates, nevertheless it can be stated that on an average adult male gibbons possess a slightly stouter trunk than adult female gibbons.

The relative shoulder breadth (biacromial diameter in percentage of trunk height) undergoes similar age changes as the previous proportion. It decreases to infantile life and thereafter increases again, particularly in males.

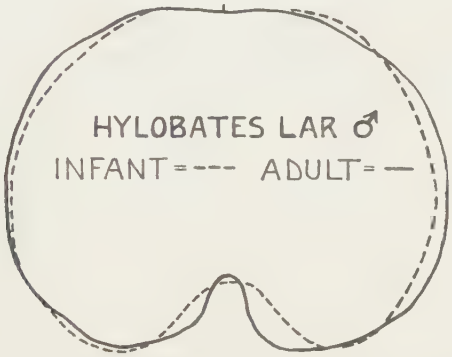

Fig. 3 Superimposed tracings of plaster casts of freshly eviscerated thoracic cavities of gibbons, cut perpendicular to thoracic spine at level of sternal insertion of fourth ribs, both reduced to same height of tracing.

The relative hip breadth (bitrochanteric diameter in percentage of trunk height) of the gibbon decreases in general with age, except for a slight, late, secondary increase. It is noteworthy that the sexes do not differ in regard to this proportion. The ranges of variations are smaller in the relative hip breadth than in the relative shoulder breadth.

The chest index (transverse diameter of chest in percentage of sagittal diameter, at same level as chest girth) becomes larger with advancing age not only in the gibbon, but also in the orang-utan and chimpanzee (fig. 2). In fetal life the two diameters of the chest are still practically alike, but after birth the transverse diameter increases more intensively than the sagittal one and this not only in the gibbon, but in the other higher primates as well, in contrast to the lower catarrhines with their relatively narrow chests at all stages of growth. The width-depth proportion of the thoracic cavity does not change with age as much as does the chest index, as shown in figure 3. The shape of the

thoracic cavity differs in young and old gibbons chiefly on account of the fact that the vertebrae are proportionately thicker and the dorsal ends of the ribs are less curved in the former than in the latter. That this is a general rule in primates is evident from the corresponding drawings for other types, published in previous papers (Schultz, '41 a, '42 a).

TABLE 3

Age changes in limb proportions of Hylobates lar (Angka series). Averages (above) and ranges of variations (omitting decimals, below). The numbers of specimens in all the age groups are the same as in table 2. For further statistical data on these indices in adults see table 10.

AGE	REL. LOWER LIMB LENGTH	REL. UPPER LIMB LENGTH	INTERMEMBRAL INDEX	CRURAL INDEX	BRACHIAL INDEX
Fetuses	140.5	213.8	151.7	80.1	93.6
	133–148	198–230	148–155	79–81	93–94
Newborns	145.5	223.6	153.7	79.8	96.0
	138–152	210–237	152–156	79–81	95–97
Infants	145.6	236.7	162.5	80.9	96.7
	136–161	222–256	159–167	75–87	93–100
Juven. I	151.6	242.1	159.5	82.5	99.0
	149–154	233–251	156–163	81–84	97–101
Juven. II	151.8	245.1	161.4	82.9	101.7
	140–162	221–260	157–168	79–86	96–106
Adults ♀	147.0	241.8	164.8	84.9	108.0
	133–160	224–266	158–172	81–91	102–113
Adults ♂	148.9	245.3	164.6	84.1	107.3
	132–166	213–274	160–171	81–88	98–113

Limbs

The percentage relations in the lengths of the limbs and of some of the limb segments are shown in table 3 and, graphically, in figure 2. The relative lower limb length (total lower limb length, or thigh length + knee height, in percentage of trunk height) undergoes rather irregular changes with age in the primates studied so far. In the gibbon this proportion increases from fetal to juvenile life, but decreases again during the last phase of growth, though not to a very marked degree. In a former publication the author ('33) had shown that this index rises in Hylobates concolor from only 104.5 in a small fetus to a maxi

mum of 169.5 in an infant, to decrease thereafter to 148.4 in the adult. In man this relation between the length of the lower extremity and the height of the trunk averages approximately 72 in the ninth week of intrauterine life, it rises rapidly until it averages 139 in the middle of the prenatal period, whereafter it drops to about 115 at birth, only to rise again during postnatal life to 170 or more in adults (Schultz, '26 a).

The relative upper limb length (total upper limb length, or upper arm length + forearm length + hand length, in percentage of trunk height) increases in general with advancing age in the gibbon. In orang-utan and chimpanzee (fig. 2), as well as in man (Schultz, '26 a), this proportion undergoes more irregular age changes. There exists as yet no explanation for these, at times very striking, differences in the rates of growth of the limbs and the trunk in different primates.

TABLE 4

Proportions of the lengths of limb bones in Hylobates lar (adults of Chiengmai series). Averages (above) and ranges of variations (omitting decimals, below). For further statistical data on these indices see table 11.

AGE & SEX	SPECIMENS	INTERMEMBRAL INDEX	CRURAL INDEX	BRACHIAL INDEX
Adults ♀	87	130.2	86.4	109.8
		124–137	81–93	104–118
Adults ♂	96 to 97	131.4	86.4	110.4
		126–136	81–93	100–118

The intermembral index (total upper limb length in percentage of total lower limb length) tends to increase with age in the gibbon, but decreases in the chimpanzee (fig. 2) and man (Schultz, '26 a), indicating that in the gibbon the upper extremity grows faster than the lower one, whereas in chimpanzee and man the reversed relation in these growth rates prevails. The lengths of the upper and the lower limbs are individually much more closely correlated than are the lengths of either of the limbs and of the trunk. This is shown by the small ranges of variations in the intermembral index compared with the ranges in the other limb proportions. The skeletal intermembral index (length of humerus + radius in percentage of length of femur + tibia) is also remarkably constant, as shown by the data in table 4.

The crural index (leg length in percentage of thigh length, or on skeleton tibia length in percentage of femur length) changes in the gibbon comparatively little during growth, namely from about 80 in

fetal life to over 84 in adults.[8] In man this proportion also tends to increase with advancing age (Schultz, '26 a).

The brachial index (forearm length in percentage of upper arm length, or on skeleton radius length in percentage of humerus length) of the gibbon becomes steadily larger with growth, the forearm being shorter than the upper arm at early stages of development, but becoming longer than the upper arm during juvenile life. In a very young

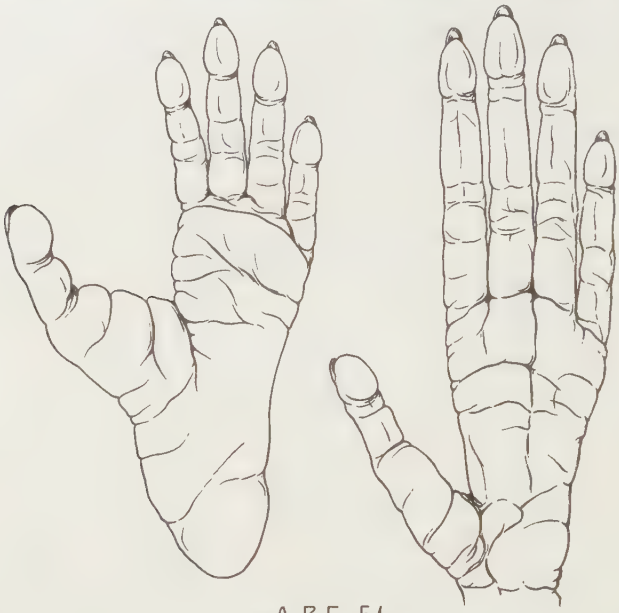

Fig. 4 Exact drawing of left foot and hand of an adult Hylobates lar (Angka series).

fetus of Hylobates concolor this index amounts to only 76.3, whereas in an adult of the same species to 115.8 (Schultz, '33 a). In chimpanzee, orang-utan (fig. 2, F) and man (Schultz, '26 a) this proportion shows the same general growth trend as it does in the gibbon, but in the latter this ontogenetic change is more marked than in the former. It is interesting to note that the ranges of variations in this index among

[8] The crural and brachial indices, derived from measurements on the outer body and given in table 3, are slightly lower than the corresponding indices, formed by skeletal measurements and listed in table 4. This discrepancy is to be expected on account of the differences in the exact location of the landmarks employed on the outer body and on the skeleton. The exact methods of measuring the long bones of the limbs are illustrated in a former paper by the author ('37).

adults are of practically the same size in the Angka series (table 3) as in the much larger Chiengmai series (table 4, seee also footnote 8).

Foot and hand

The feet and hands of adult gibbons are proportionately long and slender. The great toes and, especially, the thumbs are characterized by having an unusually long part of the first metatarsal, respectively metacarpal bone included in the free portion of these digits, as is shown by figure 4. The age changes in the main proportions of foot and hand are listed in table 5.

TABLE 5

Age changes in foot and hand proportions of Hylobates lar (Angka series). Averages (above) and ranges of variations (omitting decimals, below). The numbers of specimens in all the age groups are the same as in table 2. For further statistical data on these indices in adults see table 10.

AGE	RELATIVE FOOT LENGTH	RELATIVE HAND LENGTH	REL. FOOT BREADTH	REL. HAND BREADTH	REL. THUMB LENGTH
Fetuses	59.7	55.6	25.3	32.4	56.7
	56–64	51–60	24–26	30–35	57–57
Newborns	63.8	67.4	24.8	30.8	54.5
	60–67	63–72	24–26	29–33	54–55
Infants	60.9	67.0	22.5	25.2	51.4
	57–64	62–72	21–26	21–31	49–57
Juven. I	58.6	66.5	21.7	22.7	51.4
	58–60	64–69	21–23	22–23	51–52
Juven. II	55.0	61.9	20.4	20.8	51.6
	51–58	57–67	18–23	19–23	47–57
Adults ♀	51.6	58.9	20.5	20.2	51.9
	47–58	52–65	19–23	18–22	46–57
Adults ♂	51.6	58.7	21.0	20.7	52.0
	46–58	50–66	19–23	17–23	48–56

The relative foot length (foot length in percentage of trunk height) of the gibbon increases during late fetal life and decreases again postnatally. A corresponding age change exists in the orang-utan (Schultz, '41 a), but in the chimpanzee this index shows no initial increase, but decreases throughout the period of growth (Schultz, '40 b). The relative hand length (hand length in percentage of trunk height) of the gibbon undergoes very similar age changes as the relative foot length,

i.e., it increases until birth and decreases thereafter. Again the same holds true in regard to this index in orang-utan, whereas in chimpanzee the index drops steadily from fetal to adult life.

The percentage relations between breadth and length of the foot and of the hand are shown by the third and fourth indices in table 5. Both these proportions decrease with advancing age, but this ontogenetic change is much more marked in the hand than in the foot. That the hand becomes proportionately much narrower during growth is true also in regard to the orang-utan and the chimpanzee, except that in these apes there exists a trend to widen the hand somewhat during late juvenile life (fig. 2, G). In man the relative hand breadth also decreases ontogenetically, namely from 58 in young fetuses to about 45 in adults (Schultz, '26 a).

The last index in table 5 shows the age changes in the relative length of the thumb (thumb length from stylion in percentage of hand length) of the gibbon. On an average this proportionate length decreases from fetal to infantile life and remains practically unchanged thereafter. In orang-utan, chimpanzee and man this index also becomes generally smaller during growth, particularly in fetal life (Schultz, '26 a, '40 b, '41 a).

The proportions between the different segments of the foot change significantly with age. This is evident from the data in table 6 which show the relative lengths of the tarsal, metatarsal and phalangeal regions of the foot skeleton at different ages in the gibbon, orang-utan and man. In the former two the relative length of the tarsus becomes shortened during growth and the relative length of the phalanges becomes greater, whereas in man exactly the reversed age changes occur in these proportions. These ontogenetic trends are most strikingly shown by the percentage relation between the length of the phalanges and that of the tarsus which increases in the gibbon from 112 in a young fetus to 150 in adults and in the orang-utan from 140 in an older fetus to 168 in adults. In man this index decreases from 122 in very young fetuses to only 47 in adults. In the highly arboreal gibbon and orang-utan the feet at the completion of growth have extremely elongated phalanges and a comparatively short tarsal region, whereas in adult man the feet have become adapted to bipedal, terrestrial life by decreasing the length of the phalanges and increasing the size of the tarsus. These profound differences develop only gradually in the course of growth, as is shown by the values of the last index in table 6.

TABLE 6

Age changes in some proportions of the foot skeleton of gibbon, orang-utan and man. The fetus of H. pileatus has a sitting height of 83 mm., the "newborn" of the same species has a sitting height of 198 mm. and was probably about 2 weeks old. These indices do not differ significantly in H. pileatus and H. lar.

PRIMATE AND AGE	TARSUS LENGTH / FOOT LENGTH	METATARSUS III / FOOT LENGTH	PHALANGES III / FOOT LENGTH	PHALANGES III / TARSUS LENGTH
GIBBON				
H. pileatus fetus	32.0	32.0	36.0	112.3
H. pileatus newborn	30.7	29.0	40.3	131.5
H. pileatus adult (average of 3)	27.5	31.4	41.1	149.2
H. lar adult (average of 6)	27.6	30.5	41.9	151.6
ORANG-UTAN (Schultz, 1941 a)				
Fetus	29.6	28.9	41.5	139.9
Newborn	28.4	27.8	43.8	154.2
Adult (average of 6)	25.9	30.3	43.8	168.5
MAN (averages) (Straus, 1927)				
Fetus, 8 weeks	28.6	36.5	34.9	122.1
Fetus, 3rd month	42.9	30.7	26.4	62.4
Newborn	45.7	31.2	23.1	50.4
Adult	46.9	31.0	22.1	47.4

In all gibbons the middle digits are the longest, but the relations in length between the second and fourth digits vary considerably, inasmuch as the fourth can project beyond the second or the reversed condition can exist (fig. 4). For a former report the author ('33 a) had found the following conditions among 53 gibbons belonging to 4 different species:

Finger:	II < IV;	II = IV;	II > IV;	Toe:	II < IV;	II = IV;	II > IV
% of cases:	28	36	36		30	40	30

In the present series, consisting of 113 specimens of H. lar (Angka series), these digital formulae are distributed as follows:

Finger:	II < IV;	II = IV;	II > IV;	Toe:	II < IV;	II = IV;	II > IV
% of cases:	0	14	86		68	28	4

A second digit, shorter than the fourth, occurs in practically all non-human primates with the exception of the gibbon. It is specially noteworthy that this typically simian condition is completely lacking in

the hands of all the specimens from Doi Angka, though it is still found in 28% of other gibbons. This supports the view that variations in these relative digital lengths are of a hereditary nature. It is also mentioned in this connection that among 9 H. moloch, collected at one camp in North Borneo, the second toe is longer than the fourth in 44% of the cases.

In this chapter it remains to discuss briefly the extent to which the second and third toes are united by cutaneous webbing. This webbing is a feature widely distributed among primates, occurring not infre-

Fig. 5 Head of an adult Hylobates lar without the hair (Angka series).

quently even in man as a hereditary variation (e. g., Schultz, '22; Straus, '26; Koenner, '33). The name of the siamang (Symphalangus syndactylus) is derived from this condition. In the gibbon this webbing extends usually only to the middle of the basal phalanx II. This is the case in 89% of the specimens in the Angka series, in 100% of the specimens of H. moloch from North Borneo, and in 84% of 108 gibbons of various species, listed in a previous report by the writer ('33 a). In the latter series 12% of the specimens have this web extending to the distal end of the basal phalanx II and in the remaining 4% the web reaches even to the middle of the middle phalanx II. The latter extreme does not occur in the Angka series, though in 11% of these specimens the second and third toes are webbed along the entire basal phalanges.

Head and skull

The head of the gibbon is covered by a very dense coat of hair and thus appears to be proportionately much larger than it actually is. Without its hair the gibbon head resembles somewhat the head of a macaque, even though the face is not as protruding in the former as in the latter (fig. 5). The eyes are relatively large and far apart and the orbital rims are prominent. The main proportions appertaining to the head of the gibbon and their changes with age are shown in table 7. The growth curves for five of these head indices are illustrated in figure 2.

TABLE 7

Age changes in head proportions of Hylobates lar (Angka series). Averages (above) and ranges of variations (omitting decimals, below). The numbers of specimens in all the age groups are the same as in table 2, except in the case of adult males which number only 42. For further statistical data on these indices in adults see table 10.

AGE	REL. HEAD SIZE	REL. FACE HEIGHT	REL. UPPER FACE HEIGHT	CEPHALIC INDEX	FACE INDEX	INTEROCULAR INDEX	REL. EAR SIZE
Fetuses	68.4	35.7	35.4	86.9	41.7	30.5	6.7
	66–71	33–38	31–39	85–88	37–46	29–32	6–8
Newborns	60.8	32.0	36.9	86.9	41.9	23.5	15.2
	60–62	31–33	35–39	83–91	37–46	23–24	10–20
Infants	46.2	26.5	39.9	84.3	47.8	21.4	15.3
	42–51	24–30	38–43	79–92	44–52	19–26	12–19
Juven. I	36.9	22.4	40.2	87.0	45.8	22.4	15.0
	36–37	22–23	40–41	82–92	45–46	22–23	15–15
Juven. II	29.7	20.7	48.7	87.8	49.4	23.3	14.5
	26–36	19–24	45–53	81–92	46–53	20–28	13–17
Adults ♀	25.3	18.7	51.0	87.8	48.7	25.1	13.5
	23–28	17–20	45–59	80–94	43–58	22–30	10–16
Adults ♂	26.0	19.5	51.6	91.9	48.4	24.4	13.3
	23–30	18–22	45–58	84–102	41–56	21–28	10–16

The relative head size (arithmetic mean of head length, breadth and height in percentage of trunk height) undergoes very profound changes with age not only in the gibbon, but in all primates (fig. 2). In the Angka series this index decreases from an average of 68 in fetuses to one of only 25 or 26 in adults, i.e., postnatally the trunk grows much more intensively than does the brain part of the head. The brain itself increases in size after birth at a much slower rate than prevails in the entire body. This has been shown (Schultz, '41 b) by means of the

percentage relation between the cranial capacity (in cc.) and the body weight (in gm.) which equals 15.5 in an infantile gibbon, but averages less than 2.0 in adult gibbons. Further data and discussions pertaining to the growth of the skull capacity of the gibbon are contained in a later chapter.

The relative face height (total face height in percentage of trunk height) decreases during growth in the gibbon, as it does in chimpanzee and orang-utan (fig. 2). The gibbon has at all stages of growth a proportionately lower face than have the two great apes.

The first two indices in table 7 dealt with the relations in size between the brain part as well as the face part of the head and the trunk. The first of these relations changes with age more extensively than the second. On account of this fact it can be predicted that the relation between the size of the face part and that of the brain part also changes during growth. This latter relation is best expressed by the relative upper face height (nasion to stomion in percentage of average head diameter) which increases from fetal to adult life, due to the greater rate of growth in the face than in the brain part of the head. This ontogenetic increase is not as marked in the gibbon as it is in both the great apes shown in figure 2, K.

The cephalic index (head breadth in percentage of head length) of the gibbon decreases slightly during the earlier part of growth and increases somewhat in the beginning of juvenile life. In adult males this proportion is higher than in adult females and in two of the former specimens the head breadth actually surpasses the head length (table 7). This sex difference, as well as the late ontogenetic rise of the cephalic index, are largely due to the development of the temporal muscles which form a considerable part of the head breadth in juvenile and adult gibbons. The corresponding proportion appertaining to the skull (breadth of skull in percentage of length of skull [9]), which is shown in table 8, decreases constantly with advancing age and does not differ significantly in the two sexes (average of adult females = 77.1 and of adult males = 77.3). The brain case, therefore, does become proportionately narrower ontogenetically in the gibbon as well as in other primates (e. g., Schultz, '40 b, '41 a, '42 a). That the brain case of the gibbon also becomes relatively lower during growth, is shown by the data for the cranial length-height index in table 8.

[9] All the cranial measurements, used here, have already been described and illustrated in another paper by the author ('33).

The face index (upper face height in percentage of face breadth) of the gibbon increases in general with age, though this ontogenetic change is not as marked as it is in many other primates.

The interocular index (inner eye breadth in percentage of face breadth) of the gibbon decreases very considerably during the first part of growth and increases again in juvenile life, just as it does in the orang-utan and the chimpanzee (fig. 2, L). The eyes of the gibbon are proportionately farther apart than those of the two great apes at all corresponding stages of growth.

TABLE 8

The cranial length-breadth index (upper half of table) and the cranial length-height index (lower half of table) of Hylobates lar (Chiengmai series) at different ages. Ranges of variations, averages, standard deviations, variation coefficients, and their probable errors are given for each age group.

AGE	SPECIMENS	RANGE OF VARIATIONS	A ± E(A)	σ ± E(σ)	C + E(C)
Infants	10	80.3–94.0	86.5±0.78	3.68±0.56	4.25±0.64
Juven. I	5	80.0–92.9	85.2±1.33	4.44±0.95	5.21±1.11
Juven. II	33	75.6–91.5	80.6±0.42	3.60±0.30	4.46±0.37
Adults	182	68.3–84.8	77.2±0.15	2.93±0.10	3.80±0.13
Infants	10	69.1–77.6	72.7±0.47	2.21±0.33	3.04±0.46
Juven. I	5	68.7–73.6	71.1±0.61	2.04±0.43	2.87±0.61
Juven. II	33	63.6–76.1	69.2±0.37	3.17±0.26	4.58±0.38
Adults	182	60.2–75.9	67.8±0.14	2.89±0.10	4.26±0.15

The relative ear size (ear height × ear breadth in percentage of head length × total head height) is an accurate expression of the size of the outer ear in relation to the size of the entire head. In the gibbon the ear reaches its greatest proportionate size in infantile life, whereafter it decreases again in relative size (table 7). Orang-utans and chimpanzees also have relatively smaller outer ears in adult than in young animals (fig. 2, M). Notes and illustrations relating to the development of the detailed configuration of the outer ears of the gibbon have been published in another paper by the author ('33 a) and further observations on this subject are contained in a fragmentary, posthumous paper by Selenka ('03).

PROPORTIONS OF GIBBONS COMPARED WITH THOSE OF OTHER PRIMATES

In comparing the body proportions of gibbons with those of other primates and, particularly, in comparing the age changes in proportions we are still limited to the few types for which adequate data have

become available, hence no broad and safe generalizations can as yet be made. It is the chief purpose of this chapter to assemble and record some data, collected by uniform methods, which indicate the ontogenetic trends in some body proportions and, specially, all those conditions which are peculiar to the body build of the gibbon. For these comparisons with the gibbon have been chosen (1) the spider monkey, representing the platyrrhines as well as a type of primate which is practically as highly adapted to aboreal life by means of rapid brachiating locomotion as is the gibbon; (2) the macaque, representing a form among the lower catarrhines with conservative proportions, lacking any outstanding specialization; (3) the proboscis monkey as a representative of the catarrhine subfamily Semnopithecinae; (4 and 5) the orang-utan and chimpanzee, representing two of the great apes; (6) man. To study growth trends by comparing only two stages of development, as will be done here, naturally can not give a complete picture of the actual growth processes. A more detailed analysis of the latter must be postponed for a later publication. All data, used for the present brief comparisons, are listed in form of averages in table 9 and are illustrated in the figures 6 and 7.

The most extreme specialization in the body proportions of the gibbon consists in the enormous lengthening of the upper extremity. As shown by the diagrams in figure 6, the gibbon's upper limbs reach practically to the heels, even though the lower limbs are also of exceptional relative length, being surpassed only by the relative lower limb length of man. The lower extremity has evolved to the greatest proportionate length in man, the only bipedal primate. The gibbon possesses the second longest relative lower limb length among all primates and the ranges of variation of this proportion actually overlap in man and the gibbon.[10] Of other high specializations among the body proportions of the gibbon the brachial index is noteworthy, since it reaches the highest values among all primates in Hylobates (Schultz, '37, fig. 5), proving that the exceptional length of the gibbon's upper extremity is due most of all to the increased length of the forearm. The primates which approach the gibbon most closely in this respect are chiefly the other extreme brachiators, the siamang, the spider monkey and the orang-utan.

[10] In the Angka series of H. lar the relative lower limb length varies among adults to a maximum individual value of 166.2 (and lies above 165 in two more instances). The minimum value of this proportion in the present series of only 10 adult Negroes equals 165.1. In other human races this minimum can be even much lower, e. g., in an adult male Hawaiian, measured by the author ('33 b), is amounts to only 150.7.

Averages of 21 body proportions for 7 different primates in fetal and in adult life. All adults in these series are males. All fetuses belong to the second half of intrauterine life; the Negro fetuses are of the eighth lunar month and the average ages for the other series of fetuses correspond approximately to this stage of development in man. The data for proboscis monkeys, orang utans and chimpanzees are from previous publications by the author ('40 b, '41 a, '42 a). The data for gibbons appertain to the Angka series of this study. All other data are new (see chapter on Material).

PRIMATE	SPIDER MONKEY ATELES GEOFFROYI		MACAQUE MACACA IRUS		PROBOSCIS MONKEY NASALIS LARVATUS		GIBBON HYLOBATES LAR		ORANG-UTAN		CHIMPANZEE		NEGRO	
AGE	Fetuses	Adults	Fetuses	Adults	Fetuses	Adults	Fetuses	Adults	Fetuses	Adults	Fetuses	Adults	Fetuses	Adults
SPECIMENS	6	25	5	10	6	10	2	43	3	5	13	9	14	10
Rel. chest circumfer.	167.3	127.6	165.0	108.8	146.9	125.0	198.9	155.8	208.8	202.9	224.6	168.3	176.4	162.4
Rel. shoulder breadth	52.3	41.2	53.4	34.7	46.4	38.0	62.2	55.3	61.6	65.4	70.5	59.6	64.5	70.4
Rel. hip breadth	47.5	40.2	42.4	32.3	37.8	36.8	49.0	43.4	49.9	50.1	57.0	52.4	50.4	59.1
Chest index	101.3	106.4	95.6	90.6	95.2	99.6	99.1	117.8	110.0	129.3	115.3	127.4	118.3	135.5
Rel. lower limb length	119.0	130.8	117.0	97.6	106.9	113.6	140.5	148.9	115.4	118.2	132.6	127.1	119.6	171.9
Rel. upper limb length	169.9	179.6	150.2	116.0	141.9	137.6	213.8	245.3	202.4	202.6	193.6	171.9	126.4	158.6
Intermembral index	142.8	137.3	128.3	118.7	132.8	121.2	151.7	164.6	175.5	171.3	146.1	135.5	105.6	87.2
Crural index	91.7	95.1	91.9	88.7	85.2	88.1	80.1	84.1	85.3	85.9	83.2	83.2	81.3	85.1
Brachial index	91.1	101.5	90.8	94.7	91.5	100.3	93.6	107.3	91.3	99.7	84.3	91.8	81.1	78.0
Rel. foot length	65.7	58.0	69.4	42.7	56.9	49.4	59.7	51.6	70.5	62.9	61.5	50.7	46.2	51.3
Rel. hand length	51.9	46.9	46.0	29.0	42.3	37.5	55.6	58.7	63.8	52.4	58.4	50.0	37.3	38.5
Rel. foot breadth	28.6	21.7	27.1	23.4	26.4	23.1	25.3	21.0	29.5	26.4	29.9	26.2	27.9	25.6
Rel. hand breadth	39.3	26.4	43.7	33.6	40.3	29.0	32.4	20.7	39.6	36.7	40.7	33.8	51.1	42.8
Rel. thumb length	...	...	57.8	53.3	49.2	44.3	56.7	52.0	46.9	43.1	59.2	47.8	66.5	68.4
Rel. head size	57.2	23.8	55.6	21.8	49.2	17.1	68.4	26.0	63.6	26.5	66.6	26.3	61.4	30.2
Rel. face height	28.2	19.5	31.6	22.6	25.7	18.8	35.7	19.5	41.3	30.8	38.8	27.5	31.4	24.3
Rel. upper face height	34.7	59.2	43.1	87.3	40.5	80.0	35.4	51.6	51.0	87.6	42.8	79.0	34.1	52.4
Cephalic index	81.5	81.0	80.7	89.5	86.3	86.2	86.9	91.9	88.1	85.4	88.3	86.1	77.9	74.9
Face index	42.1	57.0	46.8	70.3	43.1	66.4	41.7	48.4	55.5	69.5	45.6	68.9	41.9	59.2
Interocular index	22.8	21.4	18.5	13.7	21.9	21.8	30.5	24.4	23.5	17.6	25.0	22.9	27.4	25.2
Rel. ear size	6.9	8.5	12.3	11.6	7.4	7.5	6.7	13.3	3.5	2.7	9.3	16.6	4.9	4.9

In several other papers the author ('33 a, '36, '40 c) has collected evidence for concluding that the gibbon belongs clearly to the small group of higher primates, composed of man and the man-like apes, and that in many respects the gibbon fills the rôle of "missing link" between the lower catarrhines on one side and man and great apes on the other

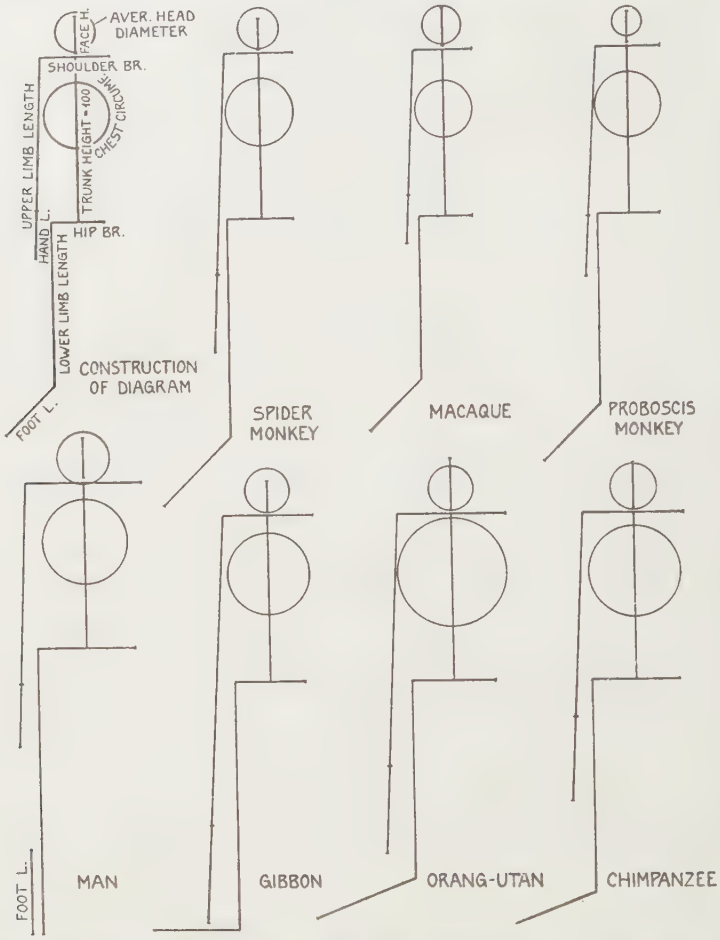

Fig. 6 Diagrammatic representation of some body proportions in the adult male primat listed in table 9. In all these figures the trunk height is the same.

That these conclusions are generally valid also in regard to body pr portions is clearly shown by the diagram in figure 7 (on the perpe dicular lines representing the adults). The gibbon stands between th group orang-utan — chimpanzee — man and the group representing th

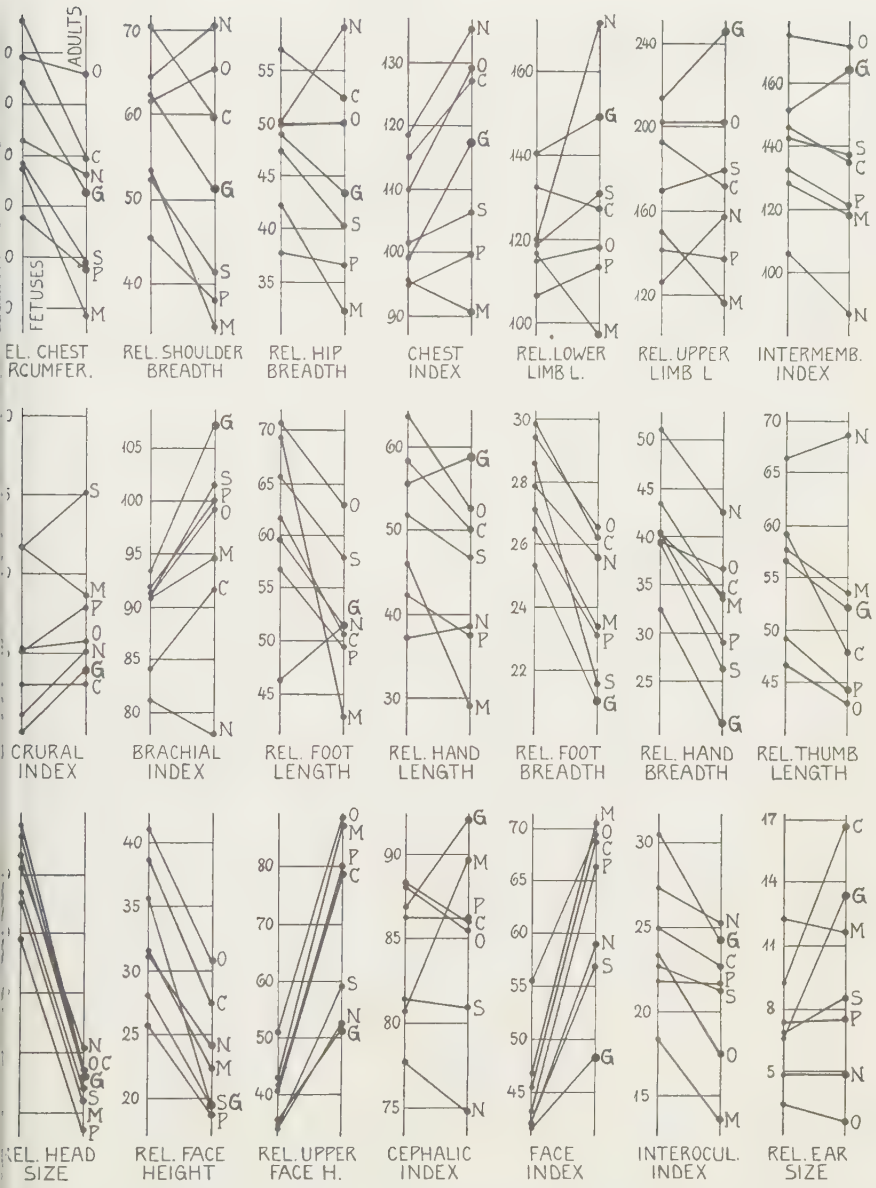

Fig. 7 The general directions of the ontogenetic changes in the proportions of some pri-ates, based upon the averages listed in table 9. In each diagram the values of fetuses are on e left and those of adults on the right perpendicular line. C= chimpanzee, G = gibbon, = macaque, N = Negro, O = orang-utan, P = proboscis monkey, S = spider monkey.

lower primates in regard to the following significant proportions: Relative chest circumference, relative shoulder breadth, relative hip breadth, chest index, and relative head size. The gibbon approaches most closely one or another of the remaining higher primates in the following proportions, besides those just mentioned: Relative upper limb length, intermembral index, crural index, relative foot length, relative hand length, relative upper face height, and interocular index. In regard to the relative foot length and the relative upper face height gibbon and man are practically identical. Even though the gibbon is much more closely related to the macaque and the proboscis monkey than to any platyrrhine primate, the spider monkey approaches the gibbon more closely than do either the macaque or the proboscis monkey in regard to a majority of these proportions. This, undoubtedly, is due to parallel evolutionary adaptations in body proportions, connected with the great similarity in locomotion in the gibbon and the spider monkey.

The general growth trends of the proportions shown in figure 7 are at times strikingly alike in all the seven primates compared. For instance, the relative chest circumference, the relative breadths of foot and of hand, the relative head size, the relative face height, and the interocular index invariably decrease with advancing age in all the primates studied and the relative upper face height and the face index undergo an ontogenetic increase in every one of these types. In contrast to this, there seems to exist a more or less pronounced lack of uniformity in regard to the age changes in some other proportions. This is at times more apparent than real and due to the fact that the present comparisons are limited to fetuses and adults. A more detailed analysis often reveals similarities in growth trends which are not evident from data appertaining to only an early and a late stage of growth. Thus, in all the primates, studied by the author so far, the relative ear size reaches its maximum values during the first period of postnatal life and decreases again subsequently in varying degrees.[1]

[1] This is shown for the gibbon, the chimpanzee and the orang-utan by the curves in figure 2 M, and for the proboscis monkey by the data in another paper (Schultz, '42 a). In the spider monkey the relative ear size averages 11.2 in 10 infants of the author's collection, or very significantly more than in either the fetuses or the adults of the same primate (table 9). No data are available for young Macaca irus, but in the closely allied Macaca mulatta the relative ear size averages 13.3 in 10 fetuses, corresponding in development to the macaque fetuses in table 9, it averages 17.6 in 10 infants of Macaca mulatta and only 15.8 in 10 adult males of the same species (part of this material has been described in a former paper by the author ['37 b], the rest are newly acquired specimens). In the Negro, finally, the relative ear size averages 5.5 in 10 newborns, again a higher value than in either fetuses or adults (table 9). It is seen, therefore, that in all these primates there exists a closely corresponding growth trend, according to which the relative ear size increases early in development, but decreases again thereafter.

ıs shown by figure 7, the general growth trends of the brachial index nd of the relative thumb length are very similar in all the primates, xcept man. In man, however, the brachial index increases, as in the ther primates, at least durnig prenatal growth, namely from an verage of 73.6 in Negro fetuses of the third month to one of 81.9 in legro fetuses of the ninth month and the relative thumb length decreases, as in the simian primates, during at least one period of growth, amely from an average of 71.6 in Negro fetuses of the third month to ne of only 65.9 in Negro fetuses of the ninth month (Schultz, '26 a). he growth trends of these proportions in man are exceptional only in egard to the postnatal period.

In conclusion of this chapter attention is called to the significant ıct that the great majority of the proportions of the primates comıared here are less different in the fetuses than in the adults. That ıe body proportions of different primates are even more similar in ill earlier ontogenetic stages, than in those used here, has been shown ı several of the writer's former publications.

VARIABILITY OF PROPORTIONS AND ASYMMETRIES

It is one of the main purposes of this chapter to record the precise onditions of variability of the metric features, discussed so far, in the bbon material of this study. The latter is of particular suitability ıd interest, inasmuch as it represents an unsually large series derived rom a limited district and collected and measured in a uniform manner. tandard deviations and variation coefficients of metric characters in on-human primates are still very scarce in the literature and are eeded in physical anthropology for basic comparisons with the corsponding statistical data appertaining to human series.

Table 10 lists the degrees of variability in the proportions of the ıter body of the adult gibbons of the Angka series and, for comparison, adult male spider monkeys from one locality. It is seen first of all at these proportions can vary in widely differing intensity. For stance, the relation between the lengths of the upper and lower exemities is very much less variable than are the relations in lengths tween the extremities and the trunk and this in all three series in ble 10. The height-width proportion of the face is more variable an the length-width proportion of the brain part of the head not only male and in female gibbons, but also in the spider monkeys. The lative shoulder breadth is much more variable than the relative hip eadth, again in all three series, and since both these indices have the

TABLE 10

Averages, standard deviations, variation coefficients, and their probable errors for the body proportions of (1) adult female Hylobates lar (37 specimens of Angka series), (2) adult male Hylobates lar (43 specimens of Angka series), and (3) adult male Ateles geoffroyi (25 specimens from Chiriqui, Panama).

1 = Gibbon ad. ♀ 2 = Gibbon ad. ♂ 3 = Spider m. ad. ♂	A ± E(A)			σ ± E(σ)			C ± E(C)		
	1	2	3	1	2	3	1	2	3
Rel. chest circumfer.	149.1±0.79	155.8±0.86	127.6±0.70	7.16±0.57	8.38±0.61	5.15±0.49	4.80±0.38	5.38±0.39	4.04±0.38
Rel. shoulder breadth	51.1±0.46	55.3±0.43	41.2±0.32	4.18±0.33	4.14±0.30	2.40±0.23	8.18±0.65	7.49±0.55	5.83±0.55
Rel. hip breadth	43.3±0.26	43.4±0.22	40.2±0.16	2.37±0.19	2.17±0.16	1.20±0.11	5.47±0.44	5.00±0.36	2.99±0.28
Chest index	116.5±0.57	117.8±0.58	106.4±0.48	5.18±0.41	5.60±0.41	3.57±0.34	4.43±0.35	4.75±0.35	3.56±0.32
Rel. lower limb length	147.0±0.82	148.9±0.77	130.8±0.72	7.43±0.59	7.52±0.55	5.33±0.51	5.05±0.40	5.05±0.37	4.07±0.39
Rel. upper limb length	241.8±1.34	245.3±1.28	179.6±0.88	12.16±0.97	12.43±0.91	6.54±0.62	5.03±0.40	5.07±0.37	3.64±0.35
Intermembral index	164.8±0.40	164.6±0.31	137.3±0.38	3.64±0.29	3.02±0.22	2.85±0.27	2.21±0.18	1.83±0.13	2.08±0.20
Crural index	84.9±0.27	84.1±0.18	95.1±0.25	2.41±0.19	1.76±0.13	1.82±0.17	2.84±0.23	2.09±0.15	1.91±0.18
Brachial index	108.0±0.32	107.3±0.31	101.5±0.34	2.93±0.23	3.02±0.22	2.53±0.24	2.71±0.22	2.81±0.20	2.49±0.24
Rel. foot length	51.6±0.30	51.6±0.28	58.0±0.30	2.72±0.22	2.74±0.20	2.20±0.21	5.27±0.42	5.31±0.39	3.79±0.36
Rel. hand length	58.9±0.37	58.7±0.36	46.9±0.24	3.36±0.27	3.48±0.25	1.81±0.17	5.70±0.46	5.93±0.43	3.86±0.37
Rel. foot breadth	20.5±0.11	21.0±0.12	21.7±0.11	0.99±0.08	1.14±0.08	0.80±0.08	4.83±0.39	5.43±0.40	3.69±0.35
Rel. hand breadth	20.2±0.11	20.7±0.13	26.4±0.14	0.96±0.08	1.28±0.09	1.04±0.10	4.75±0.38	6.18±0.45	3.94±0.37
Rel. thumb length	51.9±0.27	52.0±0.18	.....	2.46±0.20	1.76±0.13	.....	4.74±0.38	3.38±0.25	.....
Rel. head size	25.3±0.13	26.0±0.12	23.8±0.13	1.16±0.09	1.16±0.09	0.95±0.09	4.58±0.37	4.46±0.33	3.99±0.38
Rel. face height	18.7±0.12	19.5±0.11	19.5±0.13	1.05±0.08	1.08±0.08	0.95±0.09	5.62±0.45	5.54±0.41	4.87±0.46
Rel. upper face height	51.0±0.33	51.6±0.36	59.2±0.39	2.96±0.24	3.39±0.25	2.92±0.28	5.80±0.46	6.57±0.49	4.93±0.47
Cephalic index	87.8±0.43	91.9±0.37	81.0±0.35	3.90±0.31	3.53±0.26	2.61±0.25	4.44±0.35	3.84±0.28	3.22±0.31
Face index	48.7±0.35	48.4±0.31	57.0±0.36	3.19±0.26	3.02±0.22	2.64±0.25	6.55±0.52	6.24±0.46	4.63±0.44
Interocular index	25.1±0.21	24.4±0.17	21.4±0.26	1.93±0.15	1.66±0.12	1.94±0.18	7.69±0.61	6.80±0.50	9.07±0.86
Rel. ear size	13.5±0.12	13.3±0.13	8.5±0.10	1.12±0.09	1.21±0.09	0.74±0.07	8.30±0.66	9.10±0.67	8.71±0.83

same denominator (trunk height), it can be concluded that the shoulder breadth is a more variable measurement than the hip breadth.

It is seen from table 10 that in regard to the great majority of the body proportions the variation coefficients of the gibbons are higher than the corresponding coefficients of the spider monkeys. The arithmetic means of all variation coefficients (and their probable errors)[12] equal 5.21 ± 0.42 for the series of adult female gibbons, 5.24 ± 0.38 for the series of adult male gibbons, and only 4.26 ± 0.40 for the series of adult male spider monkeys. Based upon these figures it can be stated that there is no significant sex difference in regard to the variability of the body proportions in gibbons and that gibbons are in general more variable in their body proportions than are spider monkeys.

This is not the place for attempting an extensive comparison between the conditions of variability in gibbons and those in series of human beings. Only a few random samples of such comparisons will here be recorded to indicate at least in a preliminary way the degree of variability in the present series of wild simian primates, as measured in terms of the variability of modern man. The variation coefficient of the cephalic index equals 4.44 and 3.84 in adult female and male gibbons respectively. The same coefficient amounts to 4.14 in 209 adult female and to 4.69 in 169 adult male Swiss from the Bernese Oberland (Bosshart, '39), to 3.70 in 100 adult female and 3.85 in 100 adult male Germans (Fischer, '13), and to 4.22 in 8798 adult male Irish (Hooton, '40). Among colored races the variation coefficient of the cephalic index has been recorded as 3.90 in 100 adult male Papuans (Schlaginhaufen, '14), as 4.50 in 73 adult female and 4.40 in 79 adult male Marquesans (Sullivan, '23), as 4.68 in 125 adult female and 4.63 in 125 adult male Javanese from near Njalindoeng (Nyèssen, '29), and as 3.89 in 51 adult female and 3.57 in 54 adult male "Blacks" from Jamaica (Davenport and Steggerda, '29). The arithmetic mean of the variation coefficients in these twelve human series, selected merely as the first reports which came to hand on the writer's book shelves, equals 4.18, a figure half way between the values of these coefficients in female and in male gibbons. It appears, therefore, that, generally speaking, the present series of wild man-like apes does not differ significantly from human series in regard to the degree of variability of at least one of the body proportions — the cephalic index.

[12] In order to render these averages strictly comparable, the relative thumb length was omitted in the calculations, since this proportion is unobtainable in Ateles which normally has no outer thumbs.

Table 11 shows the degrees of variability of some skeletal dimension and proportions in the adult gibbons of the large Chiengmai series Dimensions of bones and the proportions based thereon can be ob tained with even greater precision and uniformity of technique tha can measurements on the outer body. Again it is found that the rela tion in length between the upper and the lower extremity is exception ally constant, the skeletal intermembral index having a variation co efficient of only 2.00 in the case of the females and of only 1.83 in th case of the males. This contrasts strikingly with the degree of varia bility in the relation between the lengths of the humerus and the cla vicle, the variation coefficients of this index lying above 5 in both sexes

TABLE 11

*Averages, standard deviations, variation coefficients, and their probable errors for som skeletal dimensions and proportions of adult gibbons (Chiengmai series). * = only 96 spec mens. All measurements taken on left side, except in cases in which a left bone was disease or broken and a measurement from the corresponding right bone had to be substituted.*

HYLOBATES LAR	87 ADULT FEMALES			97 ADULT MALES		
	A ± E(A)	σ ± E(σ)	C ± E(C)	A ± E(A)	σ ± E(σ)	C ± E(C
Length of femur (mm.)	200.6±0.68	9.41±0.48	4.68±0.24	*202.3±0.60	8.56±0.41	4.24±0.2
Length of humerus (mm).	232.2±0.73	10.17±0.52	4.38±0.22	235.9±0.72	10.28±0.49	4.36±0.2
Intermembral index	130.2±0.19	2.60±0.13	2.00±0.10	*131.4±0.17	2.40±0.11	1.83±0.0
Crural index	86.4±0.17	2.31±0.12	2.67±0.14	*86.4±0.15	2.09±0.10	2.42±0.1
Brachial index	109.8±0.21	2.89±0.15	2.63±0.13	110.4±0.23	3.32±0.16	3.01±0.1
Claviculo-humeral index	37.1±0.15	2.07±0.11	5.58±0.28	37.0±0.14	1.94±0.09	5.24±0.2

That the intermembral index has an unusually low variability and th claviculo-humeral index a very high one, holds true also in regard t many other primates, including man (Schultz, '37 a).

The percentage distribution of individual variations in these indice is shown in figure 8 by the example of the brachial index. The sam figure shows for comparison the frequency polygons for the brachia index in adult orang-utan and in adult man. In all three of these serie the ranges of variations extend over practically 20 index units. Th group of orang-utans is composed of specimens from many widel scattered regions of Borneo and of Sumatra and the human group ir

cludes many different races (Schultz, '37 a). In contrast to this, the group of gibbons contains only specimens from one small district. It is interesting to find that in the geographically very limited gibbon series variations spread over as wide a range as in the two heterogeneous series.

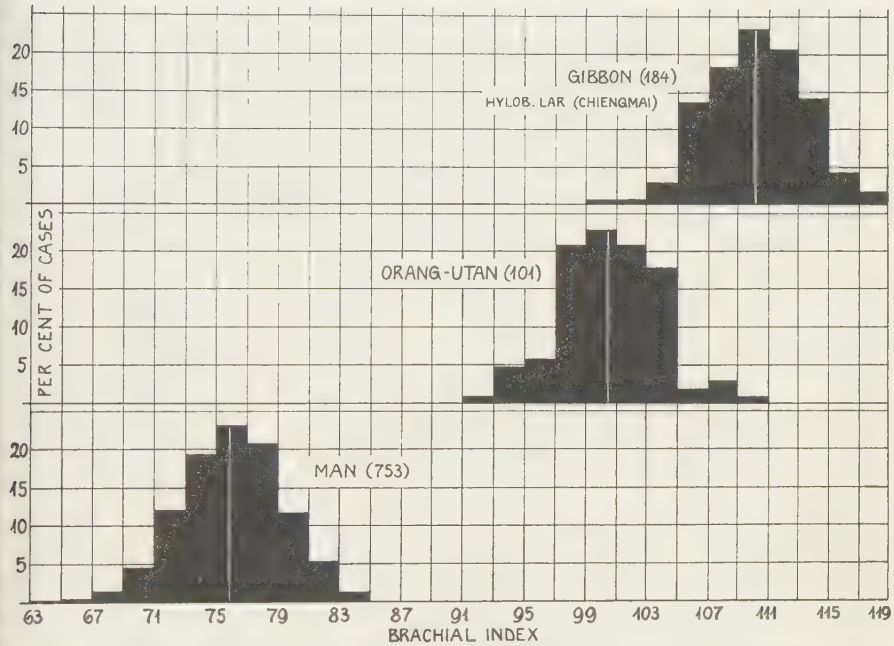

Fig. 8 Frequency polygons showing the percentage distribution of variations in the skeletal brachial index of some adult primates. The polygon for gibbon is constructed from the data appertaining to adults of the Chiengmai series; the polygon for orang-utan is based upon the material used for another study by the author ('41 a) and that for man shows the distribution of the combined variations in many different human races, as recorded in detail elsewhere (Schultz, '37 a). The perpendicular white lines indicate the position of the averages of these series.

Table 12 compares the arithmetic means of the variation coefficients of the two absolute lengths and the four indices in table 11 with the means of the same coefficients in other groups of primates which have already been recorded by the author ('37 a) in another paper, for which the genus Hylobates had been but poorly represented. These means, naturally, would indicate very little by themselves, but, being based upon exactly the same absolute and relative measurements in every case, they serve as an entirely comparable expression of the relative de-

gree of variability for each series. According to these figures, tl Chiengmai series of gibbons is practically as variable in regard these particular characters as are gorillas, female orang-utans, fema macaques, American Indians, Chinese, and male whites. All remainir groups in table 12 are slightly more variable. The average of the

TABLE 12

Arithmetic means of the variation coefficients and their probable errors of femur leng humerus length, intermembral index, crural index, brachial index, and claviculo-humeral inc for various adult primates. Gibbon according to data in table 11; all other primates accorda to Schultz ('37 a), except the series of adult ♂ Rhesus monkeys (M. mulatta) which has be increased from 19 to 36 specimens. For some of the data the total of specimens was sligh smaller than listed here, the details having been recorded in the former paper by the aut ('37 a).

PRIMATE	SEX	SPECIMENS	C ± E(C)
Gibbon	♀	87	3.66±0.18
	♂	97	3.52±0.17
White	♀	110	4.30±0.19
	♂	122	3.77±0.16
Negro	♀	111	4.18±0.19
	♂	122	4.06±0.17
Eskimo	♀	49	4.07±0.28
	♂	73	4.29±0.24
Indian	♀	54	3.74±0.24
	♂	64	3.69±0.22
Chinese	♂	39	3.54±0.27
Gorilla	♀	60	3.59±0.23
	♂	93	3.84±0.20
Chimpanzee	♀	60	4.58±0.29
	♂	45	4.33±0.32
Orang-utan	♀	39	3.58±0.29
	♂	41	4.74±0.38
Macaque (M. mulatta)	♀	60	3.48±0.21
	♂	36	4.71±0.37

figures for man equals 3.96 ± 0.22. In view of the size of the probal error, the latter value does not differ to a significant degree from t corresponding value for gibbons (3.59 ± 0.17).

Table 13 shows the statistical data appertaining to the variability the cranial length-breadth and length-height indices in adult gibbo siamangs and orang-utans, all measured by the writer in a unifo

manner. Both these indices are, on an average, lowest in the siamang and highest in the orang-utan, the various species of gibbons occupying an intermediate position regarding these two proportions. The cranial length-breadth index varies in the species H. lar between a minimum value of 68 and a maximum value of 86 and the corresponding indices of all other gibbon species do not extend this range of individual variations. On an average the gibbons of the Chiengmai series are mesocephalic, but individually they vary all the way between hyperdolichocephaly and the upper limit of brachycephaly. From figure 9

TABLE 13

The cranial length-breadth index (upper half of table) and the cranial length-height index (lower half of table) of adults of different species of Gibbon (H.), of Siamangs and of Orang-utans. The latter series has been used in another paper by the author ('41 a).

SPECIES	SPECIMENS	RANGE OF VARIATIONS	A ± E(A)	σ ± E(σ)	C ± E(C)
H. lar (Chiengmai)	182	68.3–84.8	77.2±0.15	2.93±0.10	3.80±0.13
H. lar (Malay Peninsula)	66	70.7–85.7	77.6±0.26	3.18±0.19	4.10±0.24
H. pileatus (South Siam)	17	69.5–79.7	74.3±0.46	2.79±0.32	3.75±0.43
H. moloch (many localit.)	44	68.6–83.8	76.0±0.34	3.39±0.24	4.46±0.32
H. gabrielli (Indo-China)	17	67.8–81.5	74.6±0.55	3.34±0.39	4.47±0.52
H. agilis (many localit.)	22	70.4–79.3	75.2±0.34	2.40±0.24	3.19±0.32
H. klossi (Pagi Islands)	12	70.0–78.9	75.6±0.48	2.44±0.34	3.23±0.44
Symphalangus syndactylus	31	67.7–79.8	73.4±0.39	3.20±0.27	4.36±0.37
Pongo pygmaeus (many loc.)	105	69.7–91.9	82.2±0.24	3.70±0.17	4.50±0.21
H. lar (Chiengmai)	182	60.2–75.9	67.8±0.14	2.89±0.10	4.26±0.15
H. lar (Malay Peninsula)	66	61.0–74.4	67.4±0.27	3.21±0.19	4.76±0.28
H. pileatus (South Siam)	17	60.3–66.3	63.2±0.26	1.60±0.18	2.53±0.29
H. moloch (many localit.)	44	59.2–73.1	65.7±0.33	3.22±0.23	4.90±0.35
H. gabrielli (Indo-China)	17	61.8–73.1	68.2±0.55	3.35±0.39	4.91±0.57
H. agilis (many localit.)	22	58.8–68.4	64.9±0.34	2.38±0.24	3.67±0.37
H. klossi (Pagi Islands)	12	66.7–72.0	68.8±0.33	1.68±0.23	2.44±0.34
Symphalangus syndactylus	31	54.8–65.9	60.9±0.34	2.82±0.24	4.63±0.40
Pongo pygmaeus (many loc.)	105	68.0–86.3	75.3±0.26	3.98±0.18	5.29±0.25

it is evident that the cranial length-breadth index of H. lar does not differ significantly in specimens from the Malay Peninsula and in those from the neighborhood of Chiengmai. Judging by the variation coefficients of these two skull indices, the Chiengmai series is somewhat less variable than are the series of H. moloch and of H. gabrielli, as well as the series of orang-utans. It must be mentioned, however, that of the latter series each contains specimens from many different and widely distributed localities. In table 14 are shown additional variation coefficients for these cranial indices in two series of wild monkeys

and in some human groups. The latter are random samples from the mass of similar data, available in anthropological literature. Of the two series of monkeys each was collected by the author in a very small district of eastern Nicaragua, thus they are well suited for comparison with the gibbon series from the district of Chiengmai, inasmuch as all three of these series are strictly limited regarding the localities of

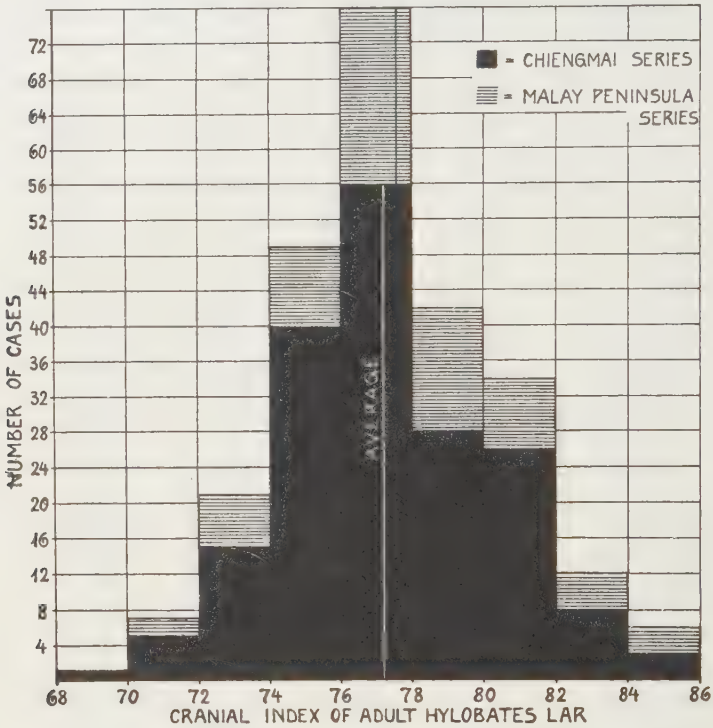

Fig. 9 Frequency polygon showing the distribution of variations in the cranial length-breadth index of adult Hylobates lar. The solid black polygon is based upon the data for the Chiengmai series, the added, shaded portions of the polygon represent the corresponding variations in adult H. lar from the Malay Peninsula (tables 8 & 13).

their origin. It is seen that the length-breadth index of the skull is much less variable in howler monkeys than in gibbons, but nearly as variable in the latter as in spider monkeys. The same index has on an average a slightly higher variation coefficient in man than in the Chiengmai series of gibbons, but there are several human groups which do not differ significantly from these gibbons regarding the degree of varia-

bility of the character under discussion. The length-height index of the skull shows practically the same variation coefficient in the Chiengmai series as in the average of the ten human series.

From these preliminary and quite incomplete comparisons regarding the variability of proportions of the outer body and of the skeleton it

TABLE 14

The variation coefficients and their probable errors of the cranial length-breadth and length-height indices in 2 species of American monkeys and in various human groups, selected at random. The probable errors for the coefficients in Bavarians have been calculated by the writer from the original data by Ried.

SERIES OF ADULTS	SEX	SPECIMENS	C ± E(C)		AUTHOR
			L.-B. Index	L.-H. Index	
Howler monkey (Alouatta palliata)	♀	60	2.75±0.17	.....	Schultz, 1926 b
	♂	50	3.03±0.20	.....	
Spider monkey (Ateles geoffroyi)	♀	24	4.20±0.43	.....	Schultz, 1926 b
	♂	15	3.94±0.48	.....	
Altai Mongols	♀ & ♂	87	4.65±0.23	4.28±0.21	Reicher, 1912
Ancient Canary Islanders (Tenerife)	♀	81	3.12±0.16	3.28±0.17	Hooton, 1925
	♂	239–245	3.03±0.09	3.40±0.10	
American Negroes	♂	82	4.82±0.25	.....	Charles, 1930
American Whites	♂	87	5.27±0.27	.....	Charles, 1930
Swiss (Eastern Alps)	♀ & ♂	55	3.71±0.24	3.48±0.24	Reicher, 1912
Austrians (Vorarlberg)	♀	26	3.76±0.30	3.88±0.36	Wacker, 1912
	♂	44	3.50±0.25	4.21±0.30	
Austrians (Carinthia)	♀	128	4.73±0.20	4.65±0.20	Shapiro, 1929
	♂	261	5.20±0.15	5.29±0.16	
Bavarians (foothills of Bavarian Alps)	♀	43	3.75±0.27	5.83±0.42	Ried, 1911
	♂	101	3.83±0.18	4.91±0.23	
Arithmetic means for man			4.11±0.22	4.32±0.24	

can be concluded tentatively that the gibbons of the Angka and the Chiengmai series possess practically the same degree of variability as the average human series. This result is rather surprising since it can be assumed that the genetic and environmental factors influencing modern man are less uniform than those appertaining to wild apes from one locality.

In a chapter devoted to variability it is appropriate to include a discussion of asymmetries since these represent, in a sense, independent variations in the two halves of the body. The problem of asymmetries in primates has already been dealt with by the author ('37 a) in another publication, for which, however, there had been comparatively few gibbons available. Table 15 shows the main results of the present study appertaining to bilateral differences in the lengths of some long bones and of the clavicles in adult gibbons. The series utilized here includes the comparatively few specimens of the former study which had been measured by the author. The total of the series fluctuates in

TABLE 15

Percentage distribution of asymmetries and averages of relative asymmetries in the long bones of the limbs and the clavicles of adult gibbons of the General Series II. The relative asymmetries express the differences between corresponding measurements on right and left bones in percentage of the smaller of the two measurements; cases of symmetry (= 0) are included in the calculation of the averages. r. > = right bone longer than left, l. > = left bone longer than right, r. = l. = right and left bones of equal length.

ASYMMETRIES OF ADULT GIBBONS		HUMERUS	RADIUS	HUMERUS + RADIUS	FEMUR	TIBIA	FEMUR + TIBIA	CLAVICLE
Total of cases		211	212	193	212	217	199	211
Percentage distribution of asymmetries	r. >	33	31	33	39	35	43	37
	l. >	40	50	52	35	35	36	43
	r. = l.	27	19	15	26	30	21	20
Average of relative asymmetries		0.59	0.65	0.46	0.63	0.65	0.48	1.73

the different columns of table 15, because no bones with healed fractures or signs of disease have been included nor any of those bones which had become extensively broken at the death of the animal. The conditions relating to asymmetries have been found to be essentially alike in the Chiengmai series and in the remainder of the gibbon material studied. For this reason only the findings for the entire and large General series II are recorded here.

The data in table 15 support the conclusion that asymmetries in the bones of the upper extremities favor the left side much more frequently than the right side, whereas in the bones of the lower extremities and in the clavicles asymmetries favor both sides with similar frequency. The average relative amounts of asymmetry in these bones is shown in the lowest row of figures in table 15. Humerus, radius, femur, and

tibia are asymmetrical in practically the same degree and very much less so than are the clavicles. The combined measurements of two adjoining limb segments are on an average less asymmetrical than are the single measurements and this regarding the upper as well as the lower extremity. By comparing the results relating to gibbons with the corresponding findings in the great apes and man (Schultz, '37 a), the following general conclusions are reached: In the bones of the upper extremities asymmetries favor the left side more frequently than the opposite side in gibbon, chimpanzee and gorilla, and the reversed condition is characteristic of orang-utan and man. No such clear preference for one side is evident in the asymmetries of the bones of the lower extremities, except in the case of man in whom the left bones are the longer ones more frequently than are the right ones. The average relative asymmetries of the limb bones are somewhat larger in the great apes than in the gibbons, but in the former, as in the latter, they are practically alike in the upper and the lower extremity. This is noteworthy, because in man the bones of the upper extremities are characterized by a much higher degree of asymmetry than exists in the bones of the lower extremities which are no more asymmetrical than those of gibbons. In the great apes and man, just as in the gibbon, the clavicles are very much more asymmetrical than any of the limb bones.

DENTITION

Sequence of eruption

The sequence of eruption of the deciduous teeth in the gibbon has been reconstructed from the findings in infantile skulls of which a total of 22 could be examined. In two of these specimens only all the incisors and lower first molars have appeared and the latter teeth are not fully out. That the first dentition of gibbons starts with the (middle) incisors is shown also by the following two cases: According to Robinson ('25) a captive-born baby of H. lar had only its four middle incisors at the age of 6 weeks and the infantile H. leucogenys, mentioned in a previous chapter, had only all four middle and the lower lateral incisors at the known age of 29 days. In another infantile gibbon skull the milk dentition is represented by all incisors and first molars, which are fully erupted, and by the canines, which are about half-way out, but the second molars are still entirely inside their alveoli. In many other skulls, finally, it is quite evident that the second molars are the last deciduous teeth to appear, since they alone do not participate in full occlusion and have not become as extensively and deeply stained as all the other

teeth. It is mentioned also that generally the lower teeth erupt slightly sooner than the corresponding upper teeth. The typical sequence of eruption in the first dentition of the gibbon is shown in table 16, where it is compared with this sequence in other primates, as far as such information has become available. From this table it can be concluded that in all these Old World primates the incisors are the first deciduous teeth to appear and that they are followed invariably by the first molars. In lower catarrhines, gibbons and man the canines are the

TABLE 16

The sequence of eruption of the deciduous teeth in gibbon and other primates, as far as known. i1 = middle incisor, i2 = lateral incisor, c = canine, m1 = first molar, m2 = second molar; symbols in parentheses indicate that the particular teeth erupt in rapid and somewhat irregular sequence.

PRIMATE	AUTHOR	SEQUENCE OF ERUPTION
Macaque	Schultz, 1933 a	i1–i2–(m1 c)–m2
Proboscis monkey	Schultz, 1942 a	(i1 i2)–m1–c–m2
Guenon	Selenka, 1899 [13]	i1–i2–m1–c–m2
Gibbon	Present study	i1–i2–m1–c–m2
Orang-utan	Schultz, 1941 a	i1–(i2 m1)–m2–c
Chimpanzee	Schultz, 1940 b	i1–i2–m1–m2–c
Gorilla	(footnote 13)	i1–i2–m1–m2–c
Man	Eidmann, 1923	i1–i2–m1–c–m2

[13] Selenka (1899) gives two diagrams showing the sequence of eruption in the first dentition of gorilla, each being based upon his findings in two infantile skulls. According to one diagram this order would be: i1 — i2 — m1 — m2 — c, but according to the other diagram the canines appear before the second molars. According to the writer's observations on 4 infantile gorillas (1 living captive, 2 preserved specimens and 1 skull, all with incomplete first dentition), the sequence of eruption is clearly that entered in table 16 which is also supported by 2 of Selenka's cases.

next teeth to erupt and the second molars are added last to the deciduous dentition. In contrast to this, the second molars erupt before the canines in all three great apes. It seems most likely that this order of eruption in the great apes represents a newly acquired specialization and that the sequence of eruption in man and gibbon is the original condition.

The sequence of eruption of the permanent teeth of the gibbon has been studied by means of the dental formulae of the 118 juvenile specimens, listed in table 17. On the basis of these data and considering also the relative frequencies of particular formulae as indications of the age intervals between the appearances of successive teeth, it is possible to construct the sequence of eruption, typical for the gibbon, as follows:

TABLE 17

Dental formulae of 118 gibbons with at least part of the permanent dentition, but without having all permanent teeth fully erupted, arranged to show the sequence of eruption of the permanent teeth. Forty of these cases are from a former paper by the author ('35). I = permanent incisor; C = permanent canine; P = permanent premolar; M = permanent molar; u. = tooth of upper jaw; l. = tooth of lower jaw; w. = wild specimen; c. = captive specimen; x = times.

SPECIMENS	DENTAL FORMULA	INCOMPLETELY ERUPTED	EXCEPTIONS (single cases)
1	iicmm / iicmmM	l. M1	iicmm / Iicmm w.
2	iicmmM / iicmmM	1 x u. M1	Iicmm / Iicmm M w.
3	iicmmM / Iicmm M	3 x l. I1 2 x u. & l. M1	
3	Iicmm M / iicmm M	1 x u. I1	
8	Iicmm M / Iicmm M	5 x u. & l. I1 1 x u. M1	
19	Iicmm M / I Icmm M	3 x l. I2	
8	I Icmm M / I Icmm M	7 x u. I2	Iicmm M / I Icmm M M w.
2	I Icmm M / I Icmm M M	2 x l. M2, 1 x u. I2	
8	I Icmm M M / I Icmm M M	3 x u. M2, 1 x u. I2	I I – P m M / I I – P m M M w.
4	I Icmm M M / I Ic P m M M	4 x l. P1	
2	I Ic P m M M / I Ic P m M M		I I c m P M M / I I c m P M M w.
1	I Ic P P M M / I I c m P M M	u. P1	I I c P P M M / – I c m m M M w.
8	I Ic P P M M / I I c P P M M	1 x u. P1 & l. P2	
6 ♀ & 3 ♂	I Ic P P M M / I I C P P M M	4 ♀ & 3 ♂ l. C	I I C P P M M / I I c P P M M w. ♀
4 ♀ & 5 ♂	I I C P P M M / I I C P P M M	9 x u. C, 1 ♂ l. C	I I c P P M M / I I c P P M M M c. ♂
1 ♀ & 1 ♂	I I c P P M M / I I C P P M M M	2 x l. C & l. M3	I I c P P M M M / I I C P P M M w. ♂
2 ♀ & 4 ♂	I I C P P M M / I I C P P M M M	3 ♂ u. C & l. M3 1 ♂ also l. C	I I c P P M M M / I I C P P M M M w. ♂
5 ♀ & 8 ♂	I I C P P M M M / I I C P P M M M	8 ♂ u. C; 3 ♂ u. M3 5 ♀ u. C; 3 ♀ u. M3 1 ♀ also l. M3	

Lower first molars; upper first molars; lower and upper middle incisors; short interval; lower lateral incisors; upper lateral incisors; lower second molars; upper second molars; short interval; lower and upper first and second premolars in rapid and irregular succession; short interval; lower canines; upper canines and lower third molars in rapid succession; upper third molars. It must be mentioned that the dental formulae in table 17 are those found in skulls of many different species of gibbons, that the eruption of a tooth, as defined here, begins when its crown reaches above the alveolar margin (not above the gum), and that a tooth is "incompletely erupted" until the state of occlusion has been attained. It is noteworthy also that only one of the many ex-

HYPOTHETICAL ORIGINAL FORMULA	M_1	M_2	M_3	I_1	I_2	P_1	P_2	C
LANGUR	M_1	M_2	I_1	I_2	M_3	[P_1	P_2]	C
ORANG-UTAN	M_1	I_1	[I_2	M_2]	[P_1	P_2]	C	M_3
CHIMPANZEE	M_1	I_1	I_2	M_2	[P_1	P_2]	C	M_3
GIBBON	M_1	I_1	I_2	M_2	[P_1	P_2]	C	M_3
FOSSIL MAN	M_1	I_1	I_2	M_2	[P_1	P_2]	C	M_3
RECENT WHITE	[M_1	I_1]	I_2	[P_1	C	P_2]	M_2	M_3

SEQUENCE OF ERUPTION OF PERMANENT TEETH

Fig. 10 Diagrammatic representation of the sequence of eruption of the permanent teeth in different primates. The teeth shown in parentheses appear in rapid and often irregular succession; the spaces between letters indicate by their relative size the intervals in dental eruption.

ceptional, atypical conditions occurs in a captive specimen. The precise sequence of eruption of the premolars varies more extensively than that of any other permanent teeth not only in the gibbon, but also in most other primates (Schultz, '35), including man (e. g., Grewel, '35). That the general order of appearance of the permanent teeth in the gibbon agrees very closely with the sequence of eruption in orang-utan, chimpanzee and fossil man, but differs extensively from the sequence characteristic of modern man, is shown by the diagram in figure 10. The evidence for and significance of the conclusions represented in figure 10 have already been discussed in former papers by the author ('35, '40 b, '41 a). The new findings appertaining to the gibbon call for no change

in the writer's earlier, general conclusions, but give the latter new support. A significant, though minor, distinction of the gibbon among simian primates consists in the lack of a marked interval between the appearances of first molars and medial incisors. Such a resting period has disappeared entirly in many human beings. It is recorded here also that the sequence of eruption in the second dentition of siamangs is exactly like that of gibbons, as far as this is apparent in nine juvenile skulls of Symphalangus, examined by the writer.

Occlusion

In the dentition of wild gibbons there exists normally perfect and uniform occlusion with the exception of the incisors which vary considerably regarding the exact relation between the upper and lower teeth. The percentage distribution of individual variations in this relation changes with age not only in the gibbon, but also in other primates, as is shown by the data in table 18. The deciduous incisors of

TABLE 18

Age changes in the relation between upper and lower incisors in gibbons (417 specimens of various species) and some other primates, the latter according to previous reports by the author ('40 b, '41 a, '42 a).

AGE	PRIMATE	TOTAL OF CASES	PERCENTAGE OF CASES WITH:		
			Underbite	Edge to edge	Overbite
INFANTILE & JUVENILE I	Proboscis m.	12	42	58	0
	Gibbon	31	*0*	*29*	*71*
	Orang-utan	24	0	71	29
	Chimpanzee	32	9	66	25
JUVENILE II	Proboscis m.	4	75	25	0
	Gibbon	67	*4*	*30*	*66*
	Orang-utan	22	4	55	41
	Chimpanzee	20	0	40	60
ADULT	Proboscis m.	26	77	23	0
	Gibbon	319	*5*	*54*	*41*
	Orang-utan	110	4	85	11
	Chimpanzee	29	7	79	14

the gibbon meet edge to edge in about one third of the cases of infants and juveniles I, and in the remaining two thirds of the cases the upper incisors project beyond the lower ones. The opposite relation between upper and lower incisors, or underbite, occurs rarely in gibbons and

was found only among permanent dentitions. Edge to edge bite is present in only slightly more than half of all adult gibbons, according to the writer's data. Colyer ('36), who has examined a total of 277 gibbons, states that: "In Hylobates, although the incisors in the adult animal usually meet 'edge-to-edge', quite a number of specimens are seen in which the upper teeth close in front of the lower teeth". The same author found underbite in 3.2% of his gibbon material which, however, has not been classified according to age. The incidence of overbite decreases with advancing age in the gibbon, as shown by table 18. In old animals with marked to extreme degrees of dental attrition overbite exists in only 25% of the (67) specimens, whereas in the youngest gibbons this condition occurs in 71%. In the proboscis monkey, on the other hand, overbite has not been observed at any stage of development. In orang-utan and chimpanzee overbite is less frequent and edge to edge bite more frequent than in the gibbon and this in all three age periods, listed in table 18.

Sex difference

In adult catarrhine primates the sexes can, as a rule, be readily determined by the size of the canines, these teeth being much larger in males than in females. The two exceptions to this rule are represented by man, in whom the canines are small in both sexes, and by gibbons (and the closely related siamangs), which possess large canines in males and in females.[14] Upon closer examination, however, it is found that even in the gibbons the canines are somewhat larger in males than in females, though this difference is not nearly as pronounced as in most other catarrhines. This fact had been observed by Kirchner (1895) in a series of Hylobates moloch (erroneously named "H. concolor"). This author even claimed that the lower canines are always longer in males than in females, if one considers the total length, including the root. The writer has measured the heights of the crowns of canines in all gibbons in which these teeth had become fully erupted, but not yet noticeably worn. Such specimens are comparatively rare. The averages and ranges of variation for these measurements are listed in table 19. It is seen that, on an average, male gibbons do have longer canines than have female gibbons, a difference which is most pronounced in H. agilis and least in H. gabrielli.

[14] Among the lower catarrhines this sex difference is least pronounced in the guenons, the females of which having canines of very considerable size, though not of quite as great a length as have males.

TABLE 19

The length of the canines in gibbons in which these teeth had become fully erupted, but not yet worn. Averages above, ranges of variations below. The length of the canine is measured (in mm.) in a straight line on the lateral side of the tooth from the edge of the alveolus to the tip of the crown.

SPECIES	SPECIMENS		UPPER CANINES		LOWER CANINES	
	♀	♂	♀	♂	♀	♂
H. lar	35	42	17.1 14–20	19.4 15–23	11.2 9–13	12.2 10–15
H. moloch	9	9	17.9 16–19	19.6 17–22	11.2 10–13	12.7 11–14
H. gabrielli	4	9	18.7 17–20	18.9 17–21	12.5 11–14	12.6 11–14
H. pileatus	4	4	17.8 16–19	18.5 18–19	12.3 11–14	13.0 12–14
H. agilis	3	4	14.7 13–16	18.0 16–20	10.3 9–12	13.0 13–13

Developmental defects

Abnormalities in the dentition of primates have been described by many authors, especially by Bateson, (1894), Schultz ('35), Bennejeant ('36), and Colyer ('36). The present study is concerned mostly with the frequency of occurrence of such dental abnormalities in gibbons. Only one developmental defect could be observed among 71 infantile or young juvenile gibbons. Of older juvenile and adult gibbons a total of 500 specimens (General series II) has been examined by the writer. Of this series 222 specimens belong to the Chiengmai series which is dealt with separately.

Marked reductions in the size of the third molars occur in the Chiengmai material in 12 specimens or in 5.4% of the cases and in the General series II in 22 specimens or in 4.4% of the cases. In 13 of the latter specimens upper third molars are the ones that have become reduced and in the remaining 9 specimens lower third molars. Seven times this reduction exists only on one side and 15 times it occurs bilaterally. In the most marked cases of reduced size there is only one root left and the crown has a maximum diameter of only 3 mm., i. e., the tooth is merely a very small peg. The extreme degree of reduction in the third molars is represented by total congenital lack of these teeth (fig. 11, G, H). This lack was recorded for 9 skulls of the Chiengmai series (= 4% and for 19 skulls of the General series II (= 3.8%). In two of these skulls all four third molars are congenitally absent and in a third skull both lower and one upper third molar

are lacking. Both upper third molars are absent in one specimen and both lower third molars in 5 other specimens. In the remaining 10 cases only one of the four last molars is absent and this 4 times in the upper and 6 times in the lower jaw. Colyer ('36) found this congenital lack of third molars in 7 out of 306 gibbons (= 2.3%) and states that the gibbon shows a clear tendency toward suppression of its last molars. With this conclusion the writer is in full agreement, particularly since such suppression exists in an even higher percentage of cases in the present material than in that examined by Colyer. Finally, it is mentioned here that among 67 adult Bornean gibbons Kirchner (1895) found absence of third molars in two specimens (= 3%). Among Old World primates the suppression of third molars has progressed most in modern man. For instance, among over 2000 adult whites, examined roentgenologically by Goblirsch ('30), one or more third molars were congenitally lacking in 9% of the cases. In the great apes third molars are very rarely undeveloped.

The congenital lack of permanent incisors was encountered in 5 Chiengmai gibbons (= 2.3%) and in 8 specimens in the General series II (= 1.6%). In only one of these skulls is an upper incisor absent (left I2). Once both lower central incisors are lacking and six times only one of these teeth. In two of these cases the absence of permanent incisors coincided with the abnormal retention of the corresponding deciduous incisors, or at least their roots (fig. 11, N).

Increases in the size and number of the permanent teeth of gibbons are much rarer than are decreases. Incomplete twinning in a tooth bud results usually in an increase in the size of the finished tooth. Such cases could be observed in 3 skulls of the Chiengmai series and in another skull among the remaining specimens of the General series II (= 0.8%). In two instances the upper right middle incisors are doubled (and fused), in one instance both lower canines show partial doubling of the crown and in a fourth instance the lower left second molar is incompletely doubled (with partial fusion at the root) (fig. 11, A,

Fig. 11 Developmental defects in the dentition of gibbons (all H. lar, Chiengmai series, except F). A = incomplete twinning of r. upper I1 in juv.; B = incomplete twinning of lower r. & l. C in juv.; C = supernumerary upper I in ad. female; D = supernumerary lower I in ad. female; E = supernumerary lower P in ad. male; F = incomplete twinning of lower M2 in ad. female H. pileatus; G = congenital lack of upper r. M3 in ad. male; H = congenital lack of lower r. & l. M3 and of one I in ad. female; I = marked crowding of lower P2 in ad. male; K = extreme lingual displacement of upper r. & l. P2 with absence of r. M1 in ad. male; L = marked lingual displacement of upper r. P2 and retention of (roots of) upper r. m2 in ad. male; M = retention of upper r. c in ad. female; N = retention of lower r. & l. i2 (left recently lost) and l. m1 with total absence of replacing permanent teeth in ad. male; O = retention of lower l. c with total absence of replacing C in ad. male.

I1
i2
c
A
A.P.E. 584
B
A.P.E. 36
C
broken
A.P.E. 142
D
A.P.E. 9
E
P1
P2
M1
P
A.P.E. 71
F
P1
P2
M1
M2
M
M3
A.S. 1264
G
M1
M2
A.P.E. 174
H
A.P.E. 2
M2
I
P1
P2
A.P.E. 109
K
P1
M1
P2
M2
M2
M3
A.S. 1576
L
P2
m2
A.P.E. 575
M
C
c
P1
A.P.E. 582
N
i2
m1
P2
A.P.E. 603
O
c
P1
A.P.E. 33

Figure 11

B, F). Supernumerary teeth are most likely the result of complete twinning of a tooth early in its formation. The single developmental defect found among young gibbons consists of a supernumerary upper right canine, impacted alongside the corresponding usual tooth in the maxillary bone of an infant H. gabrielli. Supernumerary permanent incisors exist in two Chiengmai skulls and altogether in 3 skulls of the General series II (= 0.6%). In two of these cases there are 5 well developed upper incisors and in the third case the lower incisors are 5 in number (fig. 11, C, D). Only one case of a supernumerary premolar was seen in the entire series (fig. 11, E). Extra molars have not been encountered in the Chiengmai series, but exist in 4 skulls of the remaining material of the General series II (= 0.8%). One of these skulls (H. lar, ♀, Malay Peninsula, Raffles Mus. 383) possesses fourth molars on both sides of both jaws and in addition an upper, left, fifth molar of small size. In another case there are fourth molars on both sides of the upper jaw and on the left side of the lower jaw, all three of the extra teeth being small and having each only two roots. In a third case small fourth molars exist in the lower jaw only. In the last case these extra teeth were found impacted on both sides of the upper jaw. It is significant that supernumerary incisors and molars exist in only 7 skulls, whereas the congenital absence of incisors and molars occurs in a total of 27 skulls. Extra molars, present in less than 1% of 500 gibbons, exists in 14% of over 300 orang-utans (Schultz, '41 a).

Among the developmental defects in the dentition must also be mentioned the retention of deciduous teeth beyond the period normal for their loss. Such cases were recorded for 6 adult gibbons from Chiengmai and for a total of 11 adults in the entire series (= 2.2%). Apparently all types of deciduous teeth can occasionally fail to be shed. In 7 adults milk incisors had been retained, in 2 other adults milk canines and in 3 adults milk molars. In five of these cases the retention of deciduous teeth coincided with a lack of the replacing permanent teeth, the latter lack being most likely responsible for the failure to shed the milk teeth (fig. 11, N, O). At times the permanent teeth can erupt alongside the retained teeth of the first dentition and this either in their usual position or else by being crowded out of their normal alignment (fig. 11, L, M). Crowding of permanent teeth is quite common in wild gibbons. Only the very pronounced degrees of crowding have been recorded (e. g., fig. 11, I, K, L). Such cases exist in the Chiengmai series in 15 specimens (= 6.8%) and in the General series II in 24 specimens (= 4.8%). Eleven times one or more incisors are crowded, 12 times premolars and 4 times molars, 13 times one or sev-

eral upper teeth are crowded and 12 times lower teeth. Crowded incisors are nearly always also twisted, crowded premolars are more rarely twisted. Crowding occurs more often in the lingual than in the labial direction. Extreme crowding in a dentition can result in the impaction of one or more teeth. Such impacted teeth exists in 5 adults of the Chiengmai series (= 2.2%). Four times a lateral incisor was seen to be impacted and in one case a deciduous canine (with lack of permanent C). Once a permanent incisor and 4 times premolars were found to be strikingly twisted without, however, being crowded. It remains to be mentioned here that in one adult H. lar an upper canine is decidedly rudimentary.

From this enumeration of the more noteworthy developmental defects of teeth it is evident that imperfectly formed dentitions are surprisingly common in wild gibbons, except in regard to the deciduous teeth. Such congenital malformations of one sort or another have been encountered 61 times or in 26% of the 233 H. lar of the Chiengmai series (including all ages) and 109 times or in 19% of the 579 gibbons of the General series II.

Pathological conditions

In this chapter are recorded all cases showing decay and loss of teeth and destruction or closure of alveoli among the gibbons examined. The chief interest here lies not in the details of dental pathology, but in the prevalence of the more or less extensive breaking down of the dental apparatus in gibbons having lived under natural conditions in the wild. For every dentition was recorded the occurrence of carious cavities, of clear manifestations of alveolar abscess, and of the complete loss of teeth, followed by the closure of the corresponding alveoli. A tooth is here regarded as "carious", if it contains a more or less extensive and irregular cavity, due to destruction of dental tissue, either on the crown or the neck of the tooth. As a rule, such cases are readily distinguished from the destruction of a tooth caused by erosion or extreme localized attrition during senescence (fig. 18, A, B). In the few instances in which there was any doubt regarding the diagnosis, the particular teeth have not been listed as carious. Examples of alveolar abscesses and carious cavities are shown in figure 12.

No pathological conditions were encountered in any deciduous teeth and their alveoli. The relative frequency of occurrence of disease processes in the permanent dentition of gibbons changes very markedly with advance in age, as shown by the data in table 20. Caries was not found in any juvenile gibbons and abscess formation and closed alveolus

each in only two specimens out of a total of 118 juveniles. Among adult gibbons with at most moderate attrition of the teeth caries did not occur in the Chiengmai specimens, but exists in 3 other gibbons of the General series. Among senile specimens caries becomes clearly more frequent, having been found in 8% of the Chiengmai specimens and in 9% of the old gibbons in the General series II. Kirchner (1895) describes one carious cavity in his series of 67 adult gibbons, containing an unknown number of senile specimens. Colyer ('36) lists 4 out of his 277 gibbons with caries, these 4 having together 15 carious teeth. As

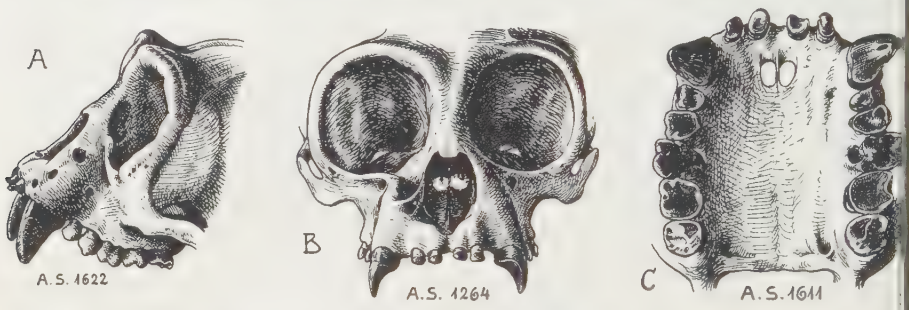

Fig. 12 Examples of pathological conditions of the dental apparatus in wild gibbons. A = alveolar abscesses on upper l. I2, C and P1 in an ad. female H. lar; B = alveolar abscess on upper r. C in an ad. female H. pileatus; C = caries in upper r. & l. M1 in an ad. female H. lar.

TABLE 20

Age changes in the percentage frequency of specimens with carious, abscessed, and lost teeth and average number of teeth affected in these specimens among gibbons of the Chiengmai series (= C.) and of the General Series II (= G. S.). The 14 infants of the Chiengmai series and the 22 infants of the General Series have not been tabulated because they showed no pathological conditions. The Chiengmai series contains a total of 244 specimens (including 11 from the Chiengmai district in the Raffles Museum) and the General Series II a total of 579 specimens.

AGE	JUVENILE		ADULT		SENILE	
SERIES	C.	G.S.	C.	G.S.	C.	G.S.
TOTAL OF SPECIMENS	46	118	146	335	38	104
CARIES						
Percentage of specimens	0	0	0	0.9	7.9	8.7
Average number of teeth	0	0	0	1.3	1.7	2.6
ABSCESS						
Percentage of specimens	4.3	1.7	11.6	7.5	57.9	38.5
Average number of teeth	1.0	1.0	1.4	1.3	2.6	2.3
CLOSED ALVEOLUS						
Percentage of specimens	4.3	1.7	5.5	3.9	21.1	22.1
Average number of teeth	2.0	2.0	1.6	1.5	1.9	2.1

this material has not been classified according to age, a comparison between Colyer's result and that of the writer is of limited value. In Colyer's series caries exists in 1.4% of the specimens, whereas in the entire present series in 2.1% of the total of cases in all age groups. The percentage frequency of abscess formation rises from 0 in infants to nearly 40 in senile specimens of the General series and to nearly 60 in the oldest group from Chiengmai. In the orang-utan these pathological conditions of the dentition are more frequent than in the gibbon, and, as in the latter, these relative frequencies increase very markedly with advance in age (Schultz, '41 a).

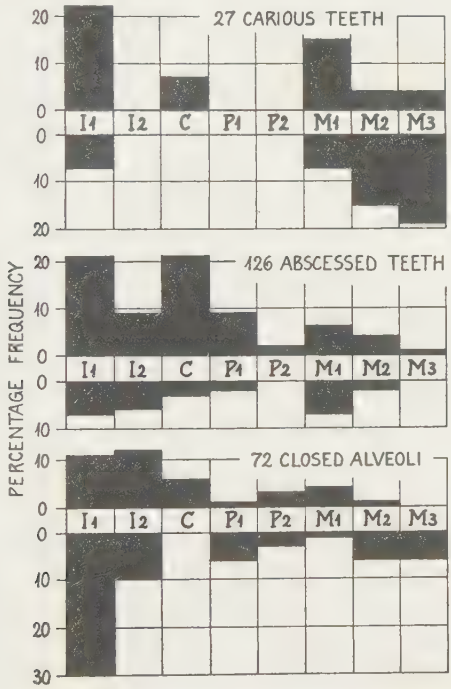

Fig. 13 Percentage frequencies with which caries, abscess and closure of alveolus are found in the different permanent teeth among the gibbons of General series II.

The loss of teeth intra vitam may be caused by a variety of factors. Accidents due to falls or fights may often be directly connected with the loss of incisors and canines. In general, however, the loss of teeth represents most likely the final result of some disease process. At any rate, abscesses, caries and closed alveoli do occur in one and the same dentition. For instance, in a wild, senile, male H. lar caries exists in

the upper, right, first molar, abscesses are present on the alveoli of the lower, right, second molar and the upper, right, first, second and third molars as well as the upper, left first and second molars; the two last mentioned teeth had become lost shortly before the death of the animal. Among the 104 senile gibbons examined only 49 show no indication of disease processes in their dentitions and the remaining 55 specimens have each at least one pathological condition, affecting one or more teeth or their sockets. That caries and alveolar abscesses in gibbons attack the different elements of the dentition with widely differing frequencies, is demonstrated in figure 13. According to this diagram, the lower middle incisors become lost more often than any of

TABLE 21

Average numbers of vertebrae in the different spinal regions in several species of gibbons and, for comparison, in siamang, man, and orang-utan; with the exception of the data for man, all averages are based upon records by the author.

SPECIES	SPECIMENS	THOR.	LUMB.	THOR.-LUMB.	SACR.	COCC.	TOTAL
Hylobates gabrielli	11	14.0	4.9	18.9	5.0	3.1	34.0
H. lar (Chiengmai Series)	231 to 232	13.1	5.2	18.3	4.5	2.7	32.5
Hylobates moloch	27 to 28	13.1	4.7	17.8	4.9	2.7	32.4
Hylobates concolor	15	12.9	4.9	17.9	4.3	1.9	31.1
Gibbon (General Series II)	308 to 314	13.1	5.1	18.2	4.6	2.7	32.5
Siamang (Symphal. syndact.)	14	12.8	4.6	17.4	4.6	2.5	31.5
Man (Schultz, '30)	745 to 3856	12.0	5.0	17.0	5.2	4.2	33.4
Orang-utan (Schultz, '41a)	103 to 107	11.9	4.0	15.9	5.4	2.6	30.9

the other teeth. Comparative data for other primates, bearing on this problem of the specific susceptibility of the various teeth to these pathological conditions, have been published elsewhere by the author ('35, '41 a).

SKELETAL DEVELOPMENT AND VARIABILITY

Spinal column and ribs

The numbers of vertebrae in the different regions of the spinal column of gibbons can vary individually to a very considerable extent. The averages of these numbers are shown in table 21. The average number of cervical vertebrae has not been tabulated because it is uniformly 7.0, if calculated to one decimal. Some species of gibbons can differ significantly from one another in regard to the average number of vertebrae in, particularly, the thoracic, sacral and coccygeal regions. For in-

stance, all specimens of H. gabrielli possess 14 thoracic vertebrae, whereas among the specimens of H. concolor all but one have 13 thoracic vertebrae, the exceptional case having only 12. Among lower catarrhines the average number of thoraco-lumbar vertebrae is commonly 19, that of sacral vertebrae 3 and that of caudal vertebrae at least 7 and usually much higher. Among all higher primates the numbers of thoraco-lumbar and caudal vertebrae have become reduced and the number of sacral vertebrae has become increased. It is seen from the data in table 21 that these phylogenetic trends are clearly recognizable in the gibbon, but the same trends have carried man and the great apes to higher extremes, except regarding the coccygeal region. The latter has become most reduced in H. concolor and least among higher primates in man. These conditions have already been discussed in another publication by the writer ('30).

The cervical region of the spine contains by far the most constant number of vertebrae in gibbons, as in all other primates. This number is 7 in 310 out of a total of 314 gibbons examined. In 3 specimens there are only 6 cervical vertebrae and in 1 specimen there are 8 (fig. 14, C, D, F). Two of the gibbons with only 6 cervical vertebrae possess 13 thoracic vertebrae and the third case has 14 thoracic vertebrae. In the specimen with 8 cervical vertebrae this regional increase is combined with 13 thoracic segments. In 2 other gibbons there exist definite cervical ribs unilaterally (fig. 14, A, B). The Chiengmai series of 232 H. lar furnished 2 cases with complete and 1 with incomplete ribs from the seventh vertebra. The other three extreme variations in the cervical region all belong to the small series of 14 H. moloch, collected in British North Borneo. It is specially mentioned also that of the latter cases two (adult female with ribs from seventh vertebra reaching manubrium and juvenile with cervical rib) occur in what undoubtedly represents a family group, namely a female, accompanied by a young gibbon and an adult male (with normal cervical region), all shot at one time and place. That the trend for such vertebral variations is a hereditary character, has been demonstrated by a number of investigators, notably Kühne ('31, '36) and Frede ('34).

The complete suppression of ribs from the eighth vertebra, or 8 cervical vertebrae, was found in only one case, but there are several instances which represent in a sense transitional stages between the usual condition and the just named, extreme variation. Thus, in one H. lar, one H. moloch (fig. 14, E, G) and one H. gabrielli the first right ribs are incompletely formed. It is evident that the border between the cervical and thoracic regions is not entirely stable in the gibbon and

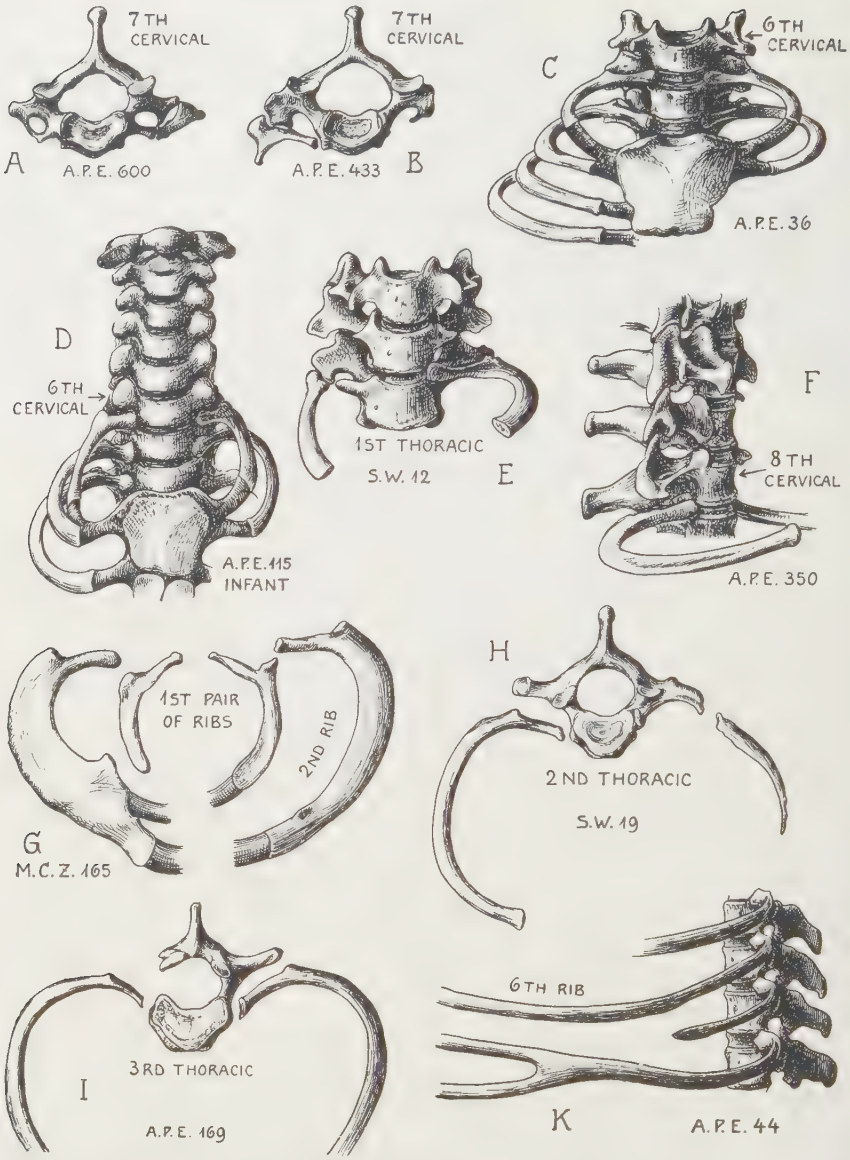

Fig. 14 Developmental variations and abnormalities of the ribs in gibbons. A and B = unilateral cervical rib on seventh vertebra; C and D = complete ribs belonging to seventh vertebra; E and G = incompletely formed first right ribs; F = congenital lack of ribs from eighth vertebra; H = abnormally formed, left, second rib; I = incomplete development of third thoracic vertebra and abnormally short neck of third, right rib; K = abnormally developed left seventh and eighth ribs. B, F and G are H. moloch, all others H. lar of the Chiengmai series.

that the seventh and eighth segments vary in this primate more frequently than they do in most other primates. Actual numerical variations in cervical vertebrae (= first ribs reaching sternum from seventh or ninth vertebra) exists in 1.3% of the 314 gibbons examined. In orang-utan such variations had been found in 3 out of 107 specimens, or in 2.8% (Schultz, '41 a). Among 170 skeletons of macaques the writer encountered 2 cases (= 1.2%) of numerical variations in cervical vertebrae.[15] In other simian primates such variations must be exceedingly rare since only 3 additional cases have been recorded, namely that of a siamang with 8 cervical vertebrae (Kohlbrügge, 1891), that of a gorilla, also with 8 cervical vertebrae (Struthers, 1893), and that of another gorilla with 6½ cervical vertebrae (Schultz, '34). Incomplete ribs belonging to the seventh vertebra, such as are recorded here for gibbons (fig. 14, A, B), have been found in many human beings. These so-called cervical ribs have also been encountered in a chimpanzee (Tredgold, 1897) and in two woolly monkeys (Straus, '37) among simian primates.

The seventh cervical vertebra lacks transverse foramina on both sides in 64% of all gibbons examined for this condition (= 264 specimens). In 23% of the cases these foramina are present on the right and left side, in 8% on the right only, and in 5% on the left only. All the other cervical vertebrae possess transverse foramina, except in one H. moloch which lacks these foramina on the seventh and sixth vertebrae and in the above mentioned three gibbons with only 6 cervical vertebrae in which the transverse foramina are lacking on the sixth vertebra bilaterally twice and unilaterally once. In man these foramina are lacking only in very rare instances, but in all other primates, examined so far, the foramina are missing on the seventh vertebrae in anywhere from 20 to 100% of the cases and in orang-utan they are absent even on the sixth and fifth vertebrae with considerable frequency (Schultz, '41 a, table 19).

The numerical variations in the postcervical vertebrae are listed in table 22. According to the author's records the number of thoracic

[15] This material is composed of the 24 macaques, examined and listed by the author ('30) for a previous publication, of 31 other macaques used for a later study (Schultz, '38 b), and of 115 new specimens in the collections of the writer's laboratory. In one of these macaques the seventh vertebra bears a pair of ribs reaching the manubrium and in another specimen the seventh vertebra has a well-formed rib on one side only.

In man there also occur numerical variations in cervical vertebrae, but the writer has been unable to find in the literature any accurate data regarding the percentage frequency of such cases. LeDouble ('12) reports that complete and incomplete cervical ribs from the seventh vertebra exist in 20 out of 902 human bodies (= 2.2%), but merely a few of these cases can be regarded as having only 6 cervical vertebrae.

vertebrae of gibbons varies between 12 and 14. Fick ('36) has published the case of a gibbon (unknown species) with only 11 thoracic (and 5 lumbar) vertebrae which is unique in the literature, even if the closely related siamangs are considered, too. The modal number is 13, and increases in this number of thoracic vertebrae are several times more frequent than are decreases. In H. lar of the Chiengmai series the last ribs are long in the 3 cases with only 12 pair of ribs and they are short, or even vestigial, in all instances with 14 pair of ribs.

TABLE 22

Numerical variations of vertebrae in the different regions of the spine for the Chiengmai series and the General Series II of gibbons. Absolute and percentage distribution of these variations.

Thoracic vertebrae		*12*	*12½*	*13*	*13½*	*14*
Chiengmai series	cases	3	2	203	4	20
232 specimens	%	1	1	87	2	9
General series II	cases	10	2	261	4	37
314 specimens	%	3	1	83	1	12

Lumbar vertebrae		*4*	*4½*	*5*	*5½*	*6*
Chiengmai series	cases	4	..	175	10	43
232 specimens	%	2	..	75	4	19
General series II	cases	15	2	240	11	46
314 specimens	%	5	1	76	3	15

Thor.-lumb. vertebrae		*17*	*17½*	*18*	*18½*	*19*
Chiengmai series	cases	1	1	164	5	61
232 specimens	%	0.5	0.5	71	2	26
General series II	cases	12	2	220	7	73
314 specimens	%	4	1	70	2	23

Sacral vertebrae		*3*	*3½*	*4*	*4½*	*5*	*5½*	*6*
Chiengmai series	cases	6	1	100	5	110	..	10
232 specimens	%	3	0.5	43	2	47	..	4
General series II	cases	6	1	126	6	159	2	14
314 specimens	%	2	0.5	40	2	51	1	4

Coccygeal vertebrae		*0*	*1*	*2*	*3*	*4*	*5*	*6*
Chiengmai series	cases	1	10	88	99	27	5	1
231 specimens	%	0.5	4	38	43	12	2	0.5
General series II	cases	1	17	116	119	43	11	1
308 specimens	%	0.5	5	38	39	14	3	0.5

Total number of vert.		*30*	*31*	*32*	*33*	*34*	*35*	*36*
Chiengmai series	cases	..	19	105	83	21	3	..
231 specimens	%	..	8	46	36	9	1	..
General series II	cases	4	37	122	97	38	9	1
308 specimens	%	1	12	40	31	12	3	0.5

The number of lumbar vertebrae varies in gibbons between 4 and 6, 5 being the modal number (table 22). An increase in the number of lumbar vertebrae occurs several times more frequently than a decrease, particularly in the Chiengmai series. Unilateral variations exist at the cranial and the caudal ends of the lumbar portion of the spine. In the General series II transitional, thoraco-lumbar vertebrae with a rib on one side and a transverse lumbar process on the opposite side are present in 6 skeletons and lumbo-sacral vertebrae with a transverse lumbar process on one side and a sacral foramen below a pars lateralis on the opposite side are present in 9 skeletons. In one of these cases unilateral variations exist at both ends of the lumbar series. The many different combinations in the numerical variations of lumbar and of thoracic vertebrae are shown in table 23. It is seen that a decrease in

TABLE 23

Absolute and percentage distribution of the combinations of variations in the numbers of thoracic and lumbar vertebrae of gibbons. 12½ and 13½ thoracic vertebrae are here counted as 13 and 14 thoracic vertebrae respectively and 4½ and 5½ lumbar vertebrae are counted as 4 and 5 lumbar vertebrae respectively.

THORACIC + LUMBAR VERTEBRAE:		*12 + 5*	*12 + 6*	*13 + 4*	*13 + 5*	*13 + 6*	*14 + 4*	*14 + 5*
Chiengmai series	cases	1	2	..	164	41	4	20
232 specimens	%	0.5	1	..	70.5	18	2	8
General series II	cases	6	4	7	214	42	10	31
314 specimens	%	2	1	3	68	13	3	10

the modal number of thoraco-lumbar vertebrae occurs in only 5% of the cases, whereas an increase in this number in 23%. It can furthermore be stated that the thoracic region has gained a segment at the expense of the lumbar region (combination 14 + 4 in table 23) in 10 cases, but the lumbar region has become increased through the transformation of a thoracic vertebra (combination 12 + 6) in only 4 cases.

The thoraco-lumbar portion of the spine of the gibbon contains anywhere from 17 to 19 vertebrae according to the writer's data (table 22). Sixteen thoraco-lumbar vertebrae exist in one of 14 siamangs examined by the author. Kohlbrügge (1891) lists a siamang with 16½ thoraco-lumbar vertebrae and Fick ('36) a gibbon with only 16 of these vertebrae. These cases represent evidently a rare condition among the Hylobatidae. Seventeen thoraco-lumbar vertebrae are present in only 1 specimen of the Chiengmai series, but occur 11 times among other gibbon species and are quite common in siamangs. The primitive con-

dition of 19 thoraco-lumbar vertebrae still persists in about one fourth of gibbons, but has disappeared among siamangs.

The number of sacral vertebrae varies between 3 and 6, 5 being the mode (table 22 and fig. 15). This is a remarkably wide range, if it is

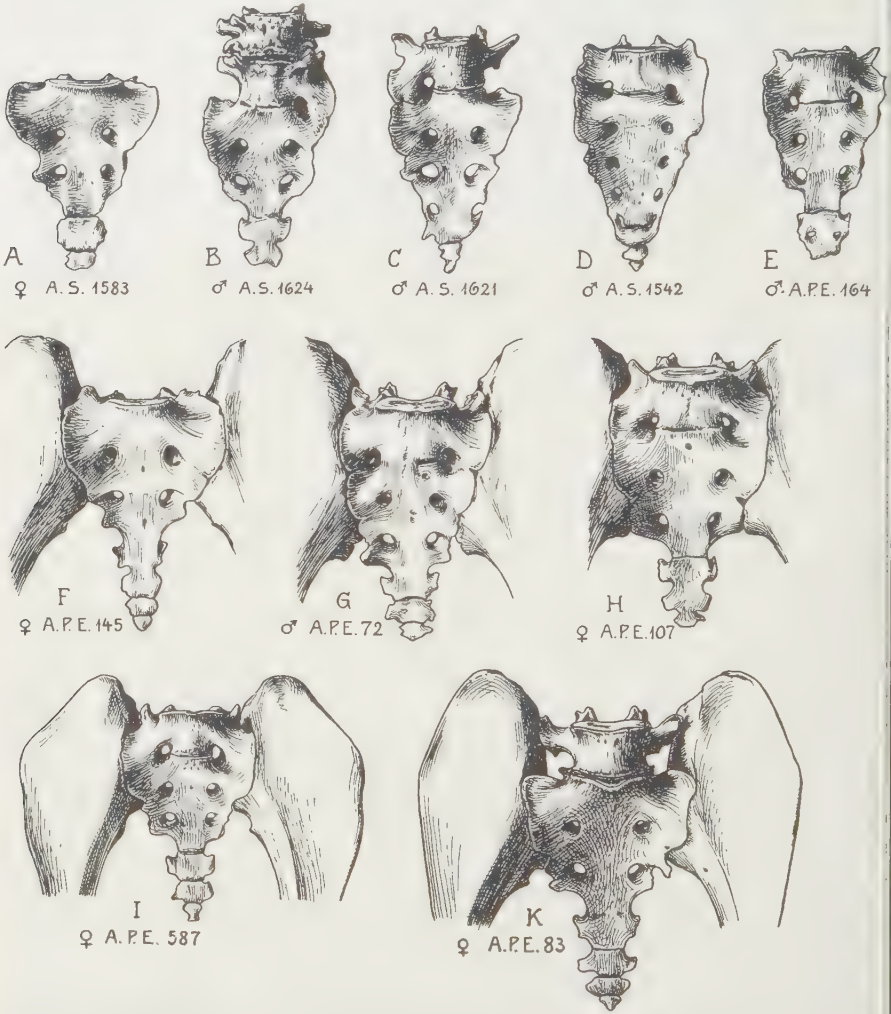

Fig. 15 Variations in the formation and position of the sacrum in gibbons. A = 3 sacra and 2 coccygeal vertebrae; B = 3½ sacral and 2 coccygeal veertebrae (note arthritic exostose on last lumbar and lumbosacral vertebra); C = 4½ sacral and 2 coccygeal vertebrae; D = 4 sacral and 2 coccygeal vertebrae; E = 4 sacral and 2 sacral-like coccygeal vertebrae; F = only first two sacral vertebrae meet ilia; G = first three sacral vertebrae meet ilia; H = all four sacral vertebrae meet ilia; I = sacrum very high between ilia; K = sacrum very low between ilia. All specimens are H. lar, except D which is H. moloch.

considered that a sacrum composed of only 3 vertebrae is characteristic of the lower catarrhines, whereas 6 sacral vertebrae represent a high specialization found in only a minority of human beings. All 6 cases with only 3 sacral vertebrae have 19 thoraco-lumbar vertebrae, whereas 13 of the 14 cases with 6 sacral vertebrae have only 18 thoraco-lumbar vertebrae, the remaining case possessing 19. The average number of thoraco-lumbar vertebrae equals 18.3 in all the gibbons (General series II) with 3 to 4 sacral vertebrae, and only 18.1 in all those gibbons with more than 4 sacral vertebrae. There does exist, therefore, a slight tendency to increase the number of vertebrae forming the sacrum at the expense of the presacral vertebral series.

TABLE 24

Averages (above) and ranges of variations (below) of the projective distance between promontory and highest point on iliac crest in percentage of ilium length in adult gibbons of the Chiengmai series. Cases with unilateral variations on lumbo-sacral border are not included.

THORACO-LUMBAR VERTEBRAE	MALES		FEMALES	
	Specimens	Index	Specimens	Index
17	0	..	1	31.5
18	69	30.0 20.0–39.3	58	28.1 18.9–34.9
19	25	36.2 28.9–43.6	24	34.3 24.1–42.3

As a general rule, the first three sacral vertebrae of gibbons are in close contact with the iliac bones, but not infrequently there are 2 or 4 vertebrae reaching the ilia (fig. 15, F, G, H). The articular surface of the sacrum actually extends, on an average, from the first to only the cranial portion of the third vertebra. The sacro-iliac ligaments are very strongly developed in the gibbon and generally reach to the fourth sacral vertebra, as has been reported also by Hakim ('37).

The position of the sacrum in relation to the hip bones varies to a remarkable degree (fig. 15, L, K). This relative position is accurately expressed by the following index: projective distance from promontory (midsagittal point on cranial, ventral border of sacrum) to level of most cranial point on iliac crest in percentage of ilium length (as defined by Schultz, '30). As shown by table 24, this proportion varies among adults of H. lar between 18.9 and 43.6 and in males the promontory is, on an average, more caudally situated in relation to the ilia than in females. It is also evident from the table that the sacrum is wedged

more deeply in the pelvic ring in specimens with 19 thoraco-lumbar vertebrae than in those with only 18. Closely corresponding results have been obtained in orang-utans (Schultz, '41 a). It appears, therefore, that a reduction in presacral segments is generally associated with a tendency to shift the position of the sacrum within the pelvic ring in a cranial direction.

The number of coccygeal vertebrae varies individually among gibbons from 0 to 6 (table 22). Since nearly all this material had been carefully prepared by the author himself, he is justified in stating that these records are complete and do include the frequently vestigial, last coccygeal elements. The various gibbon species can differ significantly regarding the degree to which the caudal portion of the spine has become reduced. Thus, in H. klossi only 4 or 5 coccygeal vertebrae have been observed and the average number equals 4.6. On the other hand in H. concolor 1, 2 and 3 coccygeal vertebrae are the only variations encountered and the average number of these vertebrae amounts to only 1.9. Among all the gibbons examined the number of coccygeal vertebrae averages 2.9 in the cases with 3 to 4 sacral vertebrae and 2.6 in the cases with more than 4 sacral vertebrae. Fifty-three per cent of the latter cases possess 2 or fewer coccygeal vertebrae; the corresponding percentage for the former cases is only 31. It appears, therefore, that the number of coccygeal vertebrae tends to decrease with an increase in sacral vertebrae and vice versa, but this inverse relation is far from complete and other factors are at work in the determination of the many and wide-spread variations in the number of coccygeal vertebrae. The sum of sacral and coccygeal vertebrae averages in the General series 7.3; it equals 5 in 1%, 6 in 18%, 7 in 43%, 8 in 27%, 9 in 9%, and 10 in 2% of the cases. This represents a remarkable variability which is very much greater than in man.

The total number of vertebrae in gibbons varies between 30 and 36, 32 being the modal number (table 22). Increases in the latter number are more frequent than are decreases. Some gibbon species differ significantly regarding this total number of vertebrae. For instance, in H. klossi this number equals 34 or 35 and averages 34.6, whereas in H. concolor it varies between 30 and 33 and averages only 31.1. The typical and statistically most frequent composition of the spinal column in gibbons is 7 cervical, 13 thoracic, 5 lumbar, 5 sacral, and 3 coccygeal vertebrae. This formula, however, occurs in only 15% of the specimens from Chiengmai and in even only 13% of the gibbons in the General series. Each of all other combinations of numerical variations in vertebrae is limited to still smaller percentages of cases. If only the

thoracic, lumbar and sacral vertebrae are considered, instead of those of all five spinal regions, the statistical norm is, naturally, found in a higher percentage of cases. According to table 25, this percentage amounts to 37 in the gibbon and to between 27 and 42 in the great apes. The corresponding figure for man is 71, that for the macaque 73 and that for the proboscis monkey 85. It is evident from these values that the combination of variations in the numbers of vertebrae is far more constant in man and lower catarrhines than in the man-like apes.

TABLE 25

Percentage frequency of occurrence of statistical norm for the numbers of thoracic, lumbar and sacral vertebrae in some series of primates. The marmosets are all Oedipomidas geoffroyi from the Panama Canal Zone, the 56 skeletons being in the author's collection. The macaques are mostly Macaca mulatta, 81 records are from former reports (Schultz, '30, '38 b) and the remaining 115 records are from new specimens in the collections of the author's laboratory. The proboscis monkeys are those described elsewhere (Schultz, '42 a). The gibbons are from the General Series II. The orang-utans consist of the series published in another paper (Schultz, '41 a) to which have been added 2 recently obtained specimens. The data for 77 of the chimpanzees have been recorded elsewhere (Schultz, '40 b) and 9 new specimens of the writer's collection have been included here. The vertebral formulae for altogether 77 gorillas have been published in former papers by the author ('30, '34, '42 b) and data on 5 additional gorillas, examined by the author, have also been used here. The data for man are those collected chiefly from the literature and published in a former paper by the author ('30).

GENUS	SPECIMENS	STATISTICAL NORM OF VERTEBRAE			PRESENT IN PER CENT OF CASES
		THOR.	LUMB.	SACR.	
Marmoset	56	12	7	3	60.7
Macaque	196	12	7	3	73.0
Proboscis monkey	46	12	7	3	84.8
Gibbon	314	13	5	5	36.6
Orang-utan	107	12	4	5	42.1
Chimpanzee	86	13	4	6	31.4
Gorilla	82	13	4	5	26.8
Man	493	12	5	5	71.2

The proportionate lengths of the various spinal regions (measured on fresh spines and including intervertebral discs) undergo changes with age, as shown by the data in table 26. The relative lengths of the cervical, thoracic and coccygeal regions decrease markedly during growth and the lumbar region increases slightly. In their direction these age changes in gibbons agree with those found in other primates (Schultz, '38 b, '40 b, '41 a, '42 a). The sex differences in these proportions, existing in adult gibbons, correspond also to those existing in other primates, though they are less marked in the gibbon than in some other forms.

The development of the vertebrae and ribs of gibbons is outlined as far as possible by the following observations. In all gibbon fetuses examined by means of x-ray photographs, there have already appeared the primary ossification centers of the vertebrae, namely one for each vertebral body and one in each hemiarch of the precaudal vertebrae. The two halves of the bony dorsal arches become fused in the midline shortly after birth as far down as the second sacral vertebra, but the spinal processes remain cartilaginous until a later age. The dorsal arches become united with the corresponding vertebral bodies during the infantile period; this process begins in the lumbar region before

TABLE 26

Averages of the lengths of the various spinal regions (measured with tape on ventral surface) in percentage of trunk height in Hylobates lar of different ages. From a former paper by the author ('38 b) and new data for a fetus, 2 newborns, an infant, and a juvenile. All specimens from Angka series, except one newborn and one infant which had been collected in other parts of Siam.

AGE	SPECIMENS	RELATIVE LENGTH OF SPINAL REGION					
		Cerv.	Thor.	Lumb.	Thor.-Lumb.	Sacr.	Coc
Fetal	1	30.0	60.0	31.1	91.1	20.0	11.[illegible]
Newborn	2	26.1	52.8	30.5	83.3	20.9	10.[illegible]
Infantile	7	25.5	52.0	32.5	84.5	18.9	9.[illegible]
Juvenile	19	23.4	50.5	32.6	83.1	19.2	6.[illegible]
Adult ♀	37	22.2	50.4	33.2	83.6	19.1	5.[illegible]
Adult ♂	43	22.4	51.1	32.2	83.3	19.3	5.[illegible]

the deciduous dentition is complete and ends in the thoracic region before any permanent teeth have appeared above their alveoli. This fusion between dorsal arch and vertebral body occurs during the middle of the infantile period in proboscis monkeys, late in the infantile period in chimpanzees, and not only early in the juvenile I period in orang-utans (Schultz, '40 b, '41 a, '42 a). In man this ossification takes place between the ages of about 4 and 7 years, according to most of the text-books of human anatomy, i. e., chiefly during the last part of the infantile period. The next happening in vertebral development is the fusion between the odontoid process and the body of the second vertebra. In the gibbon this fusion is practically complete early in the juvenile period, though traces of the previous separation can persist long and in two exceptional instances the dens epistrophei has as yet no bony connection with the corpus in specimens in which the lower second molars had become fully erupted. This particular fusion occurs also early in the juvenile II period in orang-utan, but in chimpanzee and p

boscis monkey the fusion usually takes place early in the juvenile I period and in man, on an average, during the fifth year or toward the end of the infantile period. The costal portions of the first and second (rarely third) sacral vertebrae, which develop from separate ossification centers, fuse with the bodies and transverse processes of the same vertebrae late in the juvenile I period in gibbons, early in the same period in orang-utans and at the end of the infantile period in chimpanzees. In man the corresponding age lies early in the juvenile II period (average age about 8 years, according to available information). The bony ventral arch of the atlas fuses with the ossified lateral parts of this vertebra early in the juvenile II period in gibbons and in orang-utans, whereas late in the juvenile I period in proboscis monkeys, chimpanzees and man. The average age of this fusion in man is approximately 7 years. A permanent lack of this particular fusion has been encountered in a number of gibbons, as will be described in the chapter dealing with developmental defects.

The epiphyseal plates for the bodies of the vertebrae of gibbons appear in form of more or less complete and very thin, bony rings in the juvenile II period. These epiphyses do not become fused with the vertebral bodies until after adulthood has been attained and often even not until attrition of the teeth has become quite noticeable. This holds true for gibbons as well as proboscis monkeys, orang-utans and chimpanzees. The last epiphyseal plates of the presacral vertebrae to become fused are usually those of the lower thoracic and first 1 or 2 lumbar vertebrae. In man these epiphyses begin to become ossified at the age of about 16 years and are united with the vertebral bodies at ages variously given as anywhere between 20 and 26 years, i.e., early in the adult period. Fusion between the sacral vertebrae is encountered in the gibbon, on an average, not until the specimen is adult and shows beginning wear of the dentition. This coalescence of sacral vertebrae takes place late in juvenile life in proboscis monkeys, early in adulthood in chimpanzees, later in adulthood in orang-utans (with marked wear of teeth), and very early in adulthood in man (average age for man, according to different authors, = 20 to 25 years). The age and sequence of fusion of the sacral vertebrae varies individually a great deal in all these primates and traces of the lines of separation between the bodies of some sacral vertebrae (chiefly first and second) can persist long after fusion is otherwise completed (fig. 15).

In regard to the ossification of the ribs, it is mentioned here that the epiphyses of the costal tubercles become fused with the bodies of the ribs during the juvenile II period in gibbons as well as the other pri-

mates studied by the writer. A separate epiphysis for the head of a rib disappears early in adult life in all the primates examined so far. In senile gibbons the cartilaginous portions of the ribs can become more or less extensively calcified and this most commonly in the case of the first few sternal ribs.

Sternum

The length of the sternum equals roughly one-fifth the length of the trunk in gibbons, a proportion which does not change significantly with age, as shown by the data in table 27. In comparison with the other higher primates the gibbon is characterized by a relatively short sternum (table 28). It is interesting to find that in the gibbon, as in man, the sternum is shorter, relative to trunk height, in females than in

TABLE 27

Averages of two sternal indices in Hylobates lar (Chiengmai series). The first index expresses the sternum length (without xiphoid process) in per cent of the trunk height and the second index the manubrium length in percent of the corpus sterni length.

AGE	SPECIMENS	STERNUM LENGTH / TRUNK HEIGHT	MANUBRIUM LENGTH / CORPUS LENGTH
Infantile	7	20.9	48.6
Juvenile I	4	19.4	49.9
Juvenile II	15	19.4	47.8
Adult ♀	37	20.6	...
Adult ♂	43	22.0	...
Adult ♀	87	...	42.1
Adult ♂	97	...	39.9

TABLE 28

Averages of the relative sternum length (sternum length in per cent of trunk height) of adults of great apes and man.

PRIMATE:	SPECIMENS	AUTHOR	REL. LENGTH OF STERNUM
Orang utan	6	Schultz, '41 a, and 1 new record	24.0
Chimpanzee	14	Schultz, '40 b, and 2 new records	26.3
Gorilla	4	Schultz, '30, and 1 new record	35.2
Negro ♀	5	New records	26.4
Negro ♂	10	New records	30.1
White ♂	5	New records	31.8
White ♀	25	Frey, '18	30
White ♂	35	Frey, '18	35

males.[16] The proportion in length between manubrium and corpus sterni[17] changes with age in the gibbon since the manubrium grows less intensively than the corpus (table 27). This proportion also shows a secondary sex difference in the gibbon, as it does in the orang-utan (Schultz, '41 a) and in man (Martin, '28).

In gibbons anywhere from 6 to 8 pairs of ribs reach the sternum directly. As shown by the data in table 29, the number of sternal ribs is influenced by the total number of ribs. In the gibbons of the Chiengmai series the average number of pairs of sternal ribs is 7.1, but in the series of H. gabrielli it is 7.7, all of the latter specimens having 7 or 8 pairs of sternal ribs and 14 pairs of all ribs. The corresponding average for H. moloch is only 7.0. The average number of pairs of sternal ribs amounts to 6.7 in orang-utans (Schultz, '41 a), to 7.0 in chimpanzees (Schultz, '40 b) and to 7.1 in man (378 whites, according to combined data of Tredgold, 1897, Adolphi, '05, and Frey, '18). Only

TABLE 29

Correlation between numbers of sternal ribs and numbers of all ribs in 233 gibbons of the Chiengmai series.

PAIR OF STERNAL RIBS	SPECIMENS	PAIR OF ALL RIBS			
		12 and 12½	13	13½ and 14	AVERAGE
6 and 6½	25	8%	92%	....	12.9
7	168	2%	91%	7%	13.0
7½ and 8	40	——	70%	30%	13.3

6 sternal ribs, bilaterally or unilaterally, occur in 42% of orang-utans, in 13% of chimpanzees, in 11% of gibbons (H. lar), but in only 0.5% of human beings, according to the writer's data and (for man) those of the other authors quoted above. The extreme phylogenetic reduction of the thorax on its ventral side, as manifested by only 6 pairs of sternal ribs, occurs much more frequently in anthropoid apes than in man. Finally, it is also recorded here that among the adult gibbons from Chiengmai the sternum length averages 55.7 mm. in the specimens with only 6 or 6½ pairs of sternal ribs, whereas 62.3 mm. in the specimens with 7½ or 8 pairs of sternal ribs.

[16] An identical sex difference exists also in the proboscis monkey with an average relative sternum length of 17.6 in adult females and one of 22.2 in adult males (Schultz, '42 a). Furthermore, the sternum (in relation to the length of the thoracic region) is shorter in females than in males in langurs and in macaques (Washburn, '42).

[17] Manubrium length and corpus length have to be measured in gibbons from the middle of a line connecting the costo-sternal articulations of the second pair of ribs. Most gibbons lack a sternal synchondrosis at this place and the customary osteometric landmark has to be drawn with pencil on the bone.

The ossification of the sternum of gibbons is an exceedingly variable process and, most likely on this account, the conformation and shape of the adult sternum are hardly ever alike in any two gibbons. This is clearly shown by the examples in the figures 16 and 17. The sternum of gibbons is characterized chiefly by the fact that in nearly all cases

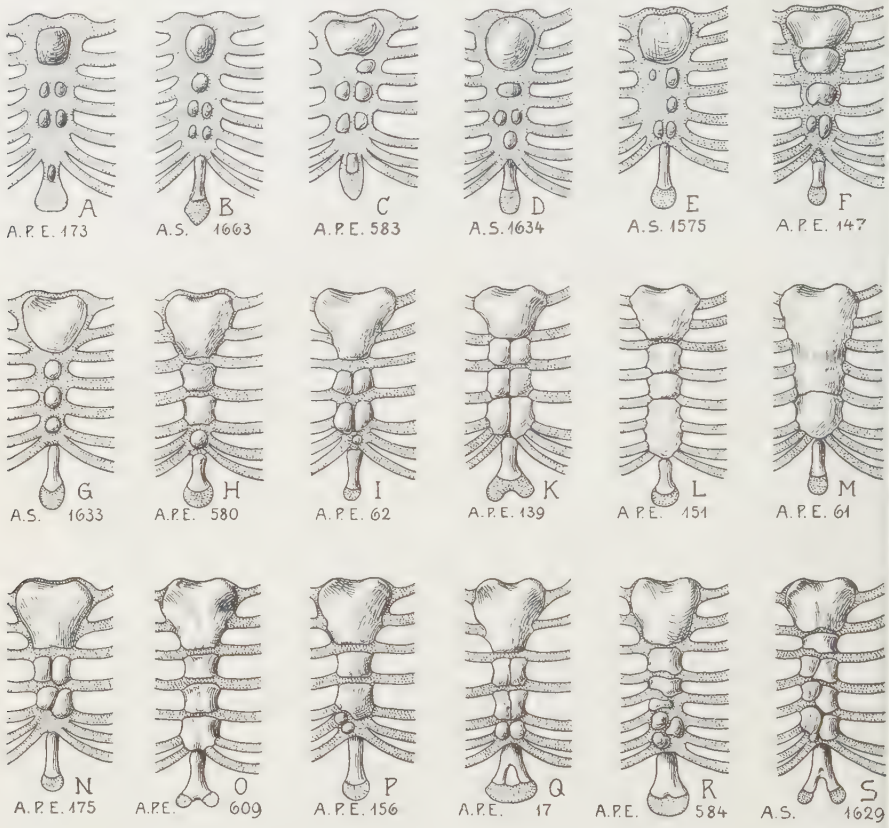

Fig. 16 Age changes and variations in the sternum of young gibbons. A to G = infants; H to M = juveniles I (the conditions of M are very exceptional); N to S = juveniles II. All specimens are H. lar, except B which is H. pileatus. Dotted areas represent cartilage.

the part corresponding to the two most cephalic intercostal segments is represented by one single bone which is the equivalent of the manubrium and the uppermost part of the corpus sterni of man and of most other primates. Such a condition has been observed in very rare instances in man (e. g., Dwight 1890). Keith (1896) estimates its frequency in man as "probably about 1 per 1000". In all 3 great apes the

manubrium can be fused with the uppermost segment of the corpus, but this only in a minority of the cases (Schultz, '30, '40 b, '41 a). The cephalic end of the sternum, as far as the third pair of ribs, becomes ossified from a single center in the majority of gibbons (fig. 16, A, B, D, E, G). More rarely one finds two or more ossification centers in this

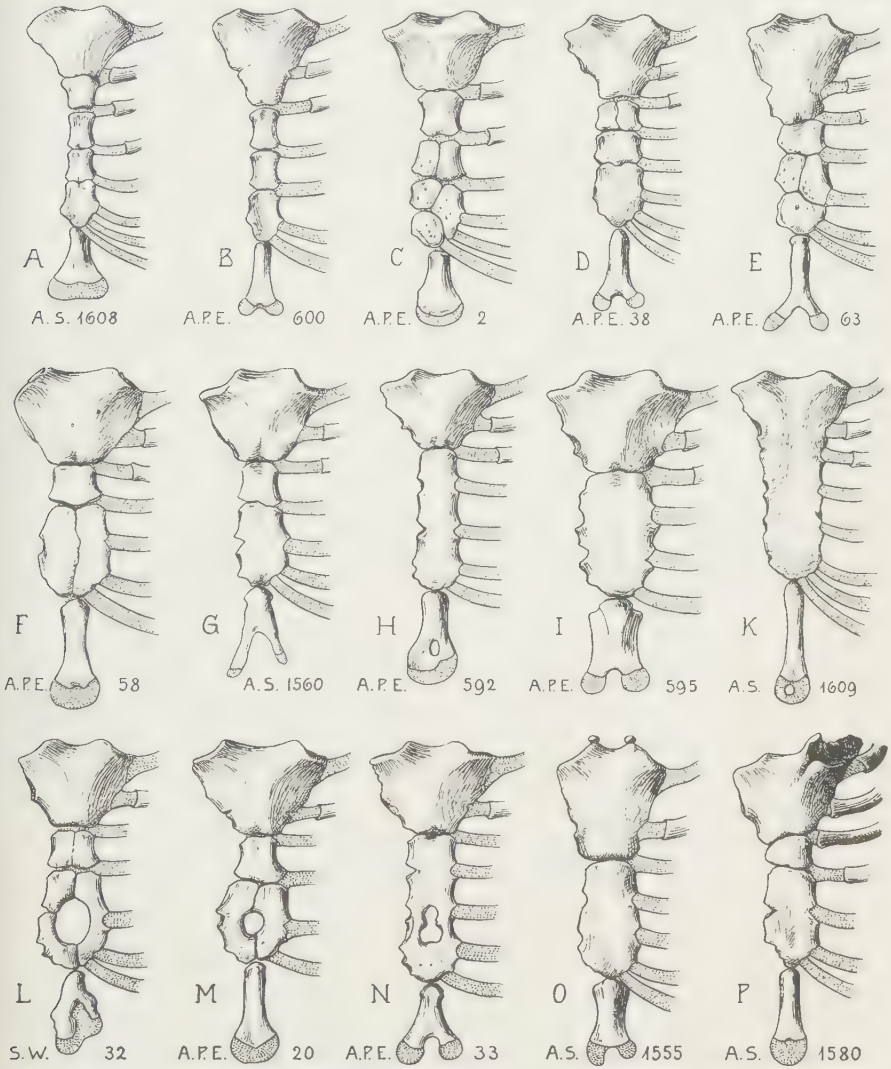

Fig. 17 Variations of the sternum of adult gibbons. All specimens are H. lar, except O which is H. moloch, showing suprasternal ossicles. P shows pathological condition on left sterno-clavicular joint.

part of the sternum, so that there exists, temporarily at least, a separate manubrium (fig. 16, C, F, K, S, fig. 17, A, C). Keith (1896) has illustrated the sternum of a newborn gibbon with a single ossification center for the manubrium and three other centers for the corpus sterni. The latter sternal part develops from as few as three and as many as eight ossification centers. Very frequently two such centers lie side by side in a sternal segment and in that case can fail to fuse in the midline even during adult life. Indeed, in 15 specimens of the Chiengmai series a considerable area in the middle of the corpus sterni has remained open to late juvenile or adult life (fig. 17, L, M, N). Such perforations in the corpus sterni occur also in man with considerable frequency.[18] In old gibbons with very marked to extreme attrition of the teeth the sternum tends to become solidified through fusion of its bony elements. This, however, is not invariably the case, as several specimens, quite evidently senile, still have their corpus sterni composed of 3 and even 4 separate bones. The xyphoid process of the gibbon develops from a separate ossification center which appears early in infantile life, if not sooner. In the large General series II there are only 2 cases in which the xyphoid process contains no bone, being entirely cartilaginous as it is in many orang-utans and chimpanzees (Schultz, '40 b, '41 a). The xyphoid process of the gibbon is very frequently forked in its bony or its cartilaginous portion. This condition is most likely connected with the bilateral ontogenetic origin of the sternum; it is also quite commonly seen in man, but it is absent in the great apes according to the writer's observations.

Separate suprasternal ossicles occur in 2 of the gibbons examined (= 0.7%). One of these cases is shown in figure 17 (O). These ossicles are quite common in man. According to the careful report by Cobb ('37) they exist in 6.8% of Whites and in 2.2% of Negroes. Never before have they been observed in primates other than man. Cobb did not find a single case among 107 great apes and the writer has not seen this primitive condition among many hundreds of monkey and ape skeletons examined, except in the 2 gibbons mentioned above.

Hip bones

The proportions of the gibbon pelvis, in comparison with the pelvic indices in other primates, have already been discussed in several former

[18] Martin ('28) quotes Ten Kate as having found this condition in 13% of South American Indians and Matiegka as having encountered it in 7% of Europeans. In the writer's collection of 30 sterna of adult Negroes there are 4 with foramina in the lower part of the corpus sterni. These openings vary in greatest diameter between 8 and 32 mm.

publications by the author ('30, '33 a, '36). The present, new material of gibbons, in which the sex is known with certainty in every instance, lends itself particularly well for an analysis of possible sex differences in the pelvis. As has been shown in an earlier chapter, the relative hip breadth of gibbons does not differ in the two sexes (table 2). The maximum breadth of the pelvic inlet, however, differs in adult male and female gibbons not only as an absolute dimension, but also in relation to

TABLE 30

The ranges of variations, averages, standard deviations, variation coefficients, and their probable errors of the absolute and relative pelvic inlet breadth and of the relative pelvic inlet height in 87 female and 96 male adult gibbons of the Chiengmai series.

CHARACTER	SEX	RANGE	A ± E(A)	σ ± E(σ)	C ± E(C)
Pelvic Inlet Breadth (mm.)	♀	47–64	55.9±0.26	3.79±0.19	6.78±0.34
	♂	43–62	51.4±0.26	3.69±0.18	7.18±0.36
Pelvic Inlet Breadth / Maximum Pelvic Breadth	♀	52.1–68.7	57.5±0.22	3.21±0.16	5.58±0.28
	♂	45.6–63.1	54.0±0.24	3.46±0.17	6.59±0.33
Promontor.-Symphysion / Ilium + Ischium l.	♀	51.2–72.8	62.2±0.26	3.71±0.19	5.96±0.30
	♂	50.7–67.1	59.9±0.24	3.39±0.17	5.66±0.28

TABLE 31

The pelvic inlet breadth in percentage of the trunk height in Hylobates lar (Angka series) at different ages.

AGE	SPECIMENS	RANGE	AVERAGE	σ ± E(σ)	C ± E(C)
Infantile	7	11.5–15.4	13.2		
Juvenile I	4	14.3–16.6	15.6		
Juvenile II	15	15.4–18.6	16.8		
Adult ♀	37	18.1–24.0	20.6±0.15	1.35±0.11	6.55±0.52
Adult ♂	42	16.7–21.4	18.9±0.11	1.11±0.08	5.87±0.41

the greatest pelvic width. This is demonstrated by the data in table 30 which also show that the sagittal diameter of the pelvic inlet is proportionately greater in adult female than in adult male gibbons. In those gibbons, in which the outer body could be measured first and the skeleton afterwards, it is found that the pelvic inlet breadth increases with age in relation to the size of the animal, as represented by the trunk height, and is greater in adult females than in adult males (table 31). Closely corresponding sex differences in these indices have been obtained for adult proboscis monkeys, orang-utans and chimpanzees (Schultz, '40 b, 41 a, '42 a). That the pelvic inlet is proportionately

larger in females than in males of langurs and macaques has been shown by Washburn ('42). It appears, therefore, that sex differences in the formation of the pelvis are not limited to man, as has often been assumed, but exist also in many other primates in which, as in man, they make their appearance after puberty. It is particularly significant that these pelvic characters show the sexual dimorphism in the gibbon, in which secondary sex differences are generally much less marked than in the majority of primates.

In all gibbon fetuses and early infants, examined by the writer, the innominate bone contains ossified zones only in its three primary elements, the ilium, ischium and pubis, which are still separate bony portions. The osseous rami of ischium and pubis are usually united at the time the deciduous dentition has become completed, but they are still separate in all gibbon infants which lack at least some of their milk teeth. The closure of these rami occurs during the latter part of the period of eruption of the deciduous dentition in orang-utan and chimpanzee (Schultz, '40 b, '41 a), but considerably later in man.

The ilium and ischium of gibbons begin their bony fusion in the region of the acetabulum toward the end of the juvenile II period. As soon as the permanent dentition is complete the ilium becomes united also with the pubis. The latter process is followed immediately by the fusion of the ischium and pubis. The last mentioned fusion is still incomplete in 8 out of 39 adult gibbons without wear of the teeth, in which ilium and ischium, as well as ilium and pubis, show finished bony union. This coalescence of the three main portions of the hip bone generally takes place during the last stage of dental eruption in the proboscis monkey, orang-utan and chimpanzee, i. e., very little earlier than in the gibbon. In man the lines of separation in the acetabular region disappear at a comparatively earlier stage of development than in the other primates, investigated so far, namely between the ages of 12½ and 15 years according to Todd ('33). A separate os acetabuli, or cotyloid bone, develops between the ilium and pubis with considerable frequency in man and in chimpanzee, but rarely in orang-utan. In gibbons such acetabular bones exist in 20 out of 44 specimens from the juvenile II period and never in younger or older specimens. Two of these gibbons with acetabular bones possess merely their first permanent molars and all permanent incisors, in all the other 18 specimens the second permanent molars have also erupted. In 5 of the latter cases the os acetabuli had become partly fused with the ilium. It evidently fuses last with the pubis.

The first bony deposits appear in the cartilaginous borders of the ischial tuberosities and the iliac crests of gibbons during the later stages of the juvenile II period. The bony rims of the tuberosities fuse with the ischial rami in the gibbon not until adulthood has been attained. These epiphyses are still entirely separate in all juvenile gibbons, they are at least partly separate in 24 out of 39 adult gibbons, showing no noteworthy attrition of the teeth, and they are completely fused in 92 out of 93 gibbons with a moderate degree of dental attrition. The bony epiphyses at the iliac crests unite with the iliac blades at an even later stage. In only 2 of 39 adult gibbons with unworn dentition has this fusion started (at the dorsal end) and in only 40 of 93 adult gibbons with moderate wear of the teeth is the fusion complete. This agrees perfectly with the corresponding findings for proboscis monkeys, orang-utans and chimpanzees (Schultz, '40 b, '41 a, '42 a), as well as those for langurs and macaques (Washburn, '43). In man these epiphyses close apparently at a somewhat earlier stage of development and in more rapid succession than in the other primates studied. Flecker ('32), e. g., gives the average age of union of these epiphyses in man as 20 to 21 years.

Bony union at the pubic symphysis has been found among adult catarrhine primates in a surprisingly high number of cases. Washburn ('42) records this condition in 1 out of 15 adult male Macaca irus, in 1 out of 12 adult male Trachypithecus pyrrhus, and in 16 out of 19 adult male and 6 out of 17 adult female Presbytis rubicunda. The writer has observed a closed pubic symphysis in an old male Nasalis larvatus, an old male orang-utan and 1 male and 2 female chimpanzees of advanced age. Table 32 shows the occurrence of symphyseal synostosis in gibbons in relation to the age and sex of the specimens. It is evident that this fusion becomes much more frequent and extensive with advance in age (= increase of attrition of the teeth), but at all ages is more common in males than in females. This closure of the pubic symphysis, very rare in man, appears to be a normal condition of old age at least in male gibbons and some species of langurs. It is noteworthy that this closure invariably starts at the cephalic end of the symphysis.

Senility in the gibbon is sometimes also accompanied by resorption of bony tissue in the iliac blades, producing extremely thin and light ilia and, eventually, one or more irregular perforations in the center of the iliac fossa. Such a case is shown in figure 18 (E). Similar symptoms of senile bony atrophy have been encountered in other skeletal parts, as will be discussed later.

TABLE 32

The degree and percentage frequency of closure of the pubic symphysis among adult gibbons (General Series I) with differing degrees of attrition of the teeth.

SEX	WEAR OF TEETH	SPECIMENS	PUBIC SYMPHYSIS: Entirely open	Upper ⅓ closed	Upper ⅔ closed	Entirely closed
♀	0	22	100	..	..	..
♂	0	17	100	..	..	..
♀	+	36	75	17	8	..
♂	+	57	49	23	18	10
♀	++	21	76	10	9	5
♂	++	17	...	24	47	29
♀	Extreme	21	67	19	9	5
♂	Extreme	20	...	20	40	40

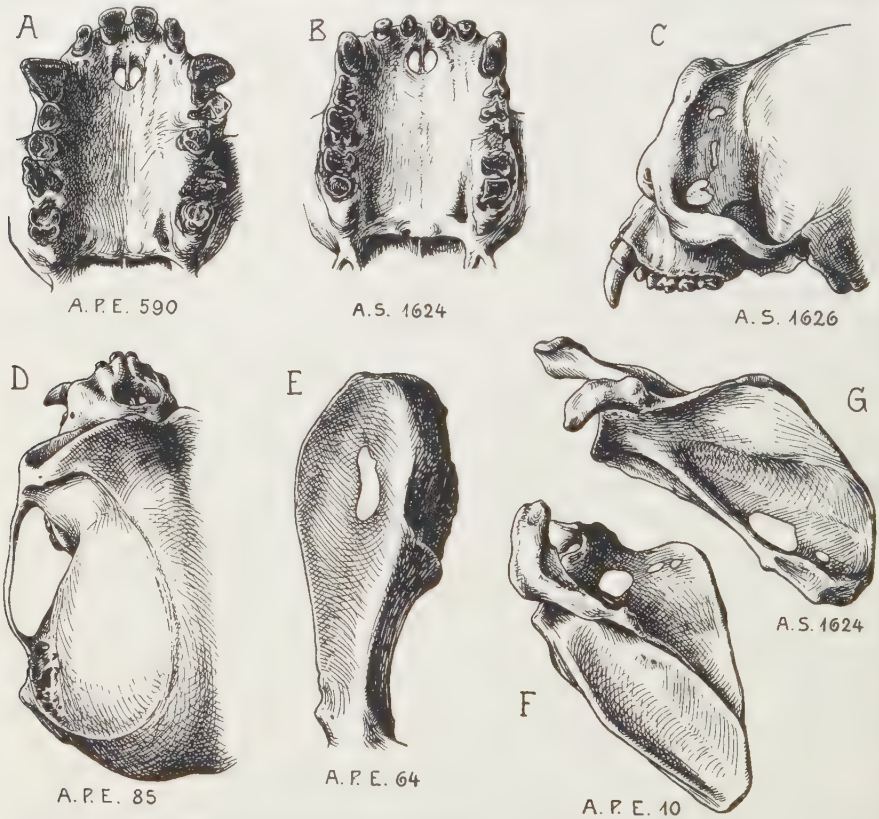

Fig. 18 Examples of dental and skeletal changes in senile gibbons (H. lar of Chiengmai series). A = r. M1 has only labial part of crown left, r. M2 lost and alveolus closed, l. M1 represented by only one root in abscessed alveolus, l. M2 with most of crown worn away; B = all teeth worn down to gums, upper l. M1 and lower r. & l. I1 lost and alveoli almost obliterated; C = perforations in orbital process of zygomatic bone; D = bony atrophy in temporal bone exposing mastoid cells; E = perforation in fossa iliaca; F and G = perforations in fossa supraspinata and in fossa infraspinata of scapula.

Shoulder girdle

The sternal epiphysis of the clavicle contains a small ossification center in many of the oldest juvenile gibbons, the center having been noted in 2 specimens as early as the period of eruption of the premolars. This clavicular epiphysis does not become completely fused with the shaft of the clavicle until some time after adulthood has been attained. The epiphysis is still separate in all adults showing no noteworthy wear of the teeth and in 12 of 93 other adults for which the degree of dental attrition has been recorded as moderate (= +). In the proboscis monkey, the orang-utan and the chimpanzee the clavicular epiphysis becomes fused in adult life and, at least in the orang-utan, not until the teeth have become moderately worn, just as in the gibbon. In man the closure of this epiphysis occurs on an average at the age of 22 years, according to Flecker ('32) and at the age of 25 years, according to Todd and D'Errico ('28).

In all gibbon fetuses examined the blade and spine of the scapula are already extensively ossified. About the time of birth there appears an ossification center in the coracoid process. This center develops even before birth in proboscis monkeys and orang-utans (Schultz, '41 a, '42 a), as well as in macaques (new observations), but after birth in the chimpanzee (new observations) and in man. The coracoid process becomes solidly joined with the shoulder blade late in the juvenile II period in gibbons and in chimpanzees. The coracoid process is firmly attached to the scapula in all adult gibbons and in 17 out of 44 gibbons, classified as juvenile II. These 17 specimens are not invariably the oldest juveniles, a fact which indicates considerable variability in the exact age of this particular fusion. In proboscis monkeys and orang-utans this union occurs slightly later, as a rule, namely at the beginning of adulthood. The corresponding age for man is usually given as 15 years.

The acromial process and the vertebral border of the scapula of gibbons are cartilaginous until late in juvenile life when small ossification centers can appear in these cartilaginous portions. The acromion still consists of 1 or 2 separate bones in 12 of 39 adult gibbons with unworn teeth and the vertebral border has a separate bony rim in 30 specimens of this same age group. Among 93 adult gibbons with a moderate degree of dental attrition the acromion has always become completely fused with the scapular spine, but the vertebral border is still, at least partly, separate in 15 specimens of this group. In general, therefore, the acromion fuses somewhat sooner than the vertebral border. The

lower angle of the scapula of gibbons can remain cartilaginous in small areas until old age is approached. These conditions in gibbons agree very closely with those in the other catarrhines, examined so far. In man the acromion and the vertebral border of the scapula usually disappear as separate epiphyses early in adult life, i.e., according to most the published statements at the approximate age of 24 years.

In senile gibbons parts of the scapular fossae are frequently reduced through bony atrophy to such a degree that irregular perforations appear in the thinnest places. Two such cases are shown in figure 18 (F, G). Practically the same conditions have been observed in very old orang-utans (Schultz, '41 a) and are not very rare among the scapulae of senile human beings.

Limb bones

The primary ossification centers of most the skeletal parts of the extremities of gibbons appear during fetal life, as could be determined by means of x-ray photographs of 9 older fetuses. At birth the gibbon lacks only some of the primary centers in the carpus and tarsus and that of the patella. Of secondary, or epiphyseal, centers the newborn gibbon possesses those at the proximal end of the humerus, at the distal end of the radius and ulna, at the distal end of the metacarpalia II to V, at the distal end of the femur, and at the proximal end of the tibia (fig. 19 and table 33). Four of these centers, however, have not yet appeared in an infant, several weeks old and having already 6 of its incisors. It seems, therefore, that the exact age of appearance of these centers can vary considerably in the gibbon, just as it does in man. In general the state of ossification of the limb bones at the time of birth has progressed slightly farther in the gibbon than in the proboscis monkey, orang-utan and chimpanzee, but not nearly as far as in the macaque (Schultz, '37 b, '40 b, '41 a, '42 a). In comparison with the average human newborn, the newborn gibbon is somewhat more advanced regarding the ossification centers of the limbs. The conditions of these centers in newborn man have been thoroughly recorded by many authors, particularly Adair and Scammon ('31), Hill ('39) and Francis and Werle ('39).

As shown by table 33, there are many differences as well as some close agreements in the relative ages and the order of appearance of the epiphyseal centers in the limbs of gibbon and man. For instance, the centers present in the youngest gibbons appear in man also during the early months after birth, except the center for the distal epiphysis of the ulna and the secondary centers of the metacarpalia. The trochlea humeri develops a bony center at the beginning of the period of erup-

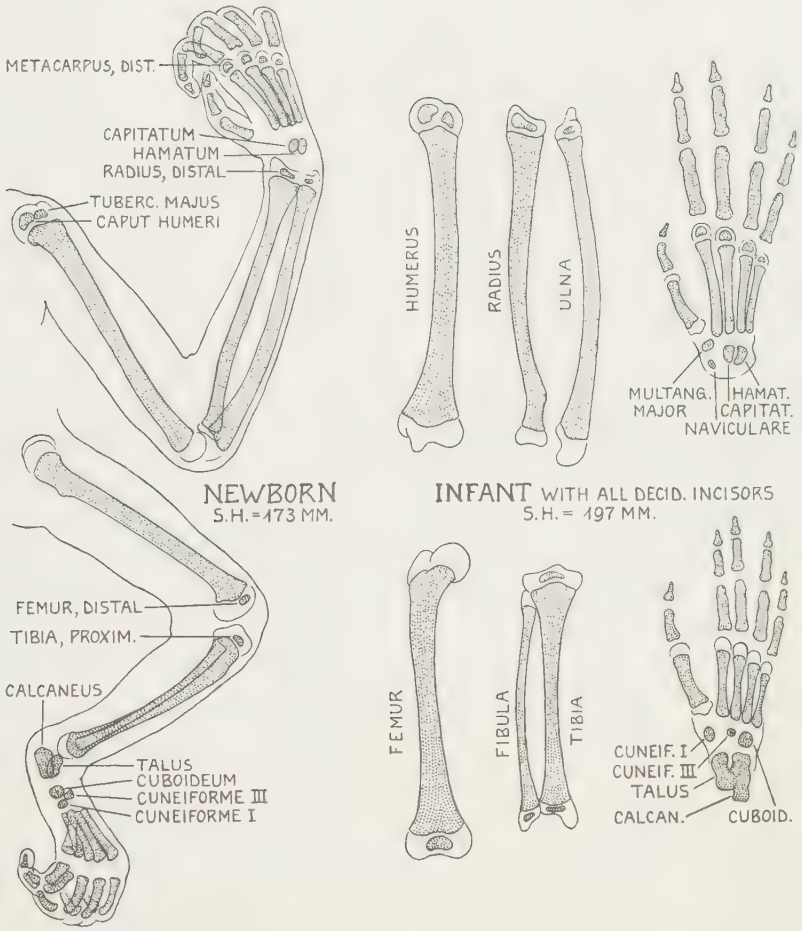

Fig. 19 Tracings of x-ray photographs of the extremities of a newborn and of an infantile Hylobates lar. The latter was prepared as a wet skeleton. The former is about 8 days old, its ossification centers are listed in the first column of table 33. All tracings reduced the same amount.

tion of the permanent teeth in gibbons, or at an age which in man would be the seventh year. According to most accounts this center appears in man much later. On the other hand, ossification in the patella [19] of the gibbon starts generally also with the juvenile I period, but in man the center of the patella appears already in the middle of the infantile

[19] The patella usually becomes ossified from a single center. In 1 infant gibbon, however, there are two centers in one patella and even three separate bony nodules in the other.

TABLE 33

The ages of appearance of ossification centers in the bones of the extremities of gibbons during postnatal growth and, for comparison, the average ages at which these centers appear in male Whites according to Francis and Werle ('39). C = ossification centers; + = present; 0 = absent; numbers in parentheses give cases with centers whenever these centers are absent in other specimens of the same series; y. = year; m. = month.

AGE	YOUNG GIBBONS						NORMAL AGE OF APPEARANCE OF CENTERS IN MALE WHITES (Francis and Werle, '39)
	INFANTILE				JUVEN. I	JUVEN. II	
DENTITION	No teeth	6 to 8 incisors	8 incisors + 4 molars	All decid. teeth	1st perm. molars	Without premolars	* = according to text-books of Human Anatomy
SPECIMENS	1	2	1	14	7	20	
Head of humerus	+	+	+	+	+	+	Birth
Gr. tuberosity of humerus	+	+ (1)	+	+	+	+	7 m.
Fusion between above 2 C	0	0	0	+ (10)	+	+	5 y.*
Capitulum humeri	0	0	+	+	+	+	3 m.
Trochlea humeri	0	0	0	+ (2)	+ (6)	+	12 y.*
Med. epicondyle of humerus	0	0	0	0	+ (3)	+	5 y. +
Radius, proximal	0	0	0	+	+	+	3 y. 10 m.
Ulna, proximal	0	0	0	0	0	+ (10)	10 y.*
Radius, distal	+	+	+	+	+	+	7 m.
Ulna, distal	+	+ (1)	+	+	+	+	5 y. +
Carpus (number of C)	2 C	3 to 4 C	6 C	7 to 8 C	all C	all C	2 m. (2 C) to 4 y. 8 m. (all C)
Metacarpalia, distal	+	+	+	+	+	+	1 y. 1 m. to 1 y. 10 m.
Phalanges, proximal	0	0	0	+ (4)	+	+	11 m. to 2 y. 5 m.
Head of femur	0	0	+	+	+	+	3 m.
Great trochanter	0	0	0	+ (10)	+	+	3 y. 1 m.
Small trochanter	0	0	0	0	+ (4)	+	13 y.*
Femur, distal	+	+	+	+	+	+	Birth
Patella	0	0	0	+ (2)	+	+	3 y. 1 m.
Tibia, proximal	+	+ (1)	+	+	+	+	Birth
Fibula, proximal	0	0	0	+ (4)	+ (5)	+	2 y. 11 m.
Tibia, distal	0	+	+	+	+	+	3 m.
Fibula, distal	0	+ (1)	+	+	+	+	6 m.
Tarsus (number of C)	5 C	5 to 6 C	6 C	all C	all C	all C	Birth (3 C) to 1 y. 9 m. (all C)
Tuber calcanei	0	0	0	0	0	+ (6)	10 y.*
Metatarsalia, distal	0	0	0	+	+	+	1 y. 10 m. to 3 y. 8 m.
Phalanges, proximal	0	0	0	+ (3)	+	+	11 m. to 5 y. +

period, i. e., at the age of 3 years. The full significance of the order of development of these centers will become apparent only after many more data on these conditions in other primates have been recorded.

The process of bony fusion between the epiphyses and shafts of the limb bones begins in the gibbon in the juvenile II period after the second permanent molars have appeared and before any premolars have erupted. In several specimens of this stage of dental development the distal epiphysis of the humerus has become partly united with the diaphysis. The corresponding epiphyseal line is obliterated in all but 2 gibbons with at least some erupted premolars. From table 34 it is seen that

TABLE 34

The sequence of fusion in the epiphyses of the long bones of 69 gibbons with incomplete closure of epiphyseal lines. o = open; p = partly fused; F = completely fused; j = juvenile; a. = adult; Prox. = proximal epiphysis; Dist. = distal epiphysis; Epic. = medial epicondyle; G. tr. = great trochanter; S. tr. = small trochanter.

SPECIMENS	HUMERUS			RADIUS		ULNA		FEMUR				TIBIA		FIBULA	
	Prox.	Dist.	Epic.	Prox.	Dist.	Prox.	Dist.	Head	G.tr.	S.tr.	Dist.	Prox.	Dist.	Prox.	Dist.
4 j.	o	p	o	o	o	o	o	o	o	o	o	o	o	o	o
3 j.	o	F	o	o	o	o	o	o	o	o	o	o	o	o	o
4 j.	o	F	p	o	o	p	o	o	o	o	o	o	o	o	o
6 j.	o	F	p	o	o	F	o	o	o	o	o	o	o	o	o
4 j.	o	F	F	o	o	p	o	o	o	o	o	o	o	o	o
6 j. 3 a.	o	F	F	o	o	F	o	o	o	o	o	o	o	o	o
1 a.	o	F	F	o	o	F	o	o	o	F	o	o	o	o	o
1 a.	o	F	F	F	o	F	o	o	o	p	o	o	o	o	o
1 a.	o	F	F	o	o	F	o	F	F	F	o	o	o	o	o
1 a.	o	F	F	p	o	F	o	p	F	F	o	o	o	o	o
2 a.	o	F	F	F	o	F	o	p	F	F	o	o	o	o	o
3 a.	o	F	F	F	o	F	o	F	F	F	o	o	o	o	o
1 a.	o	F	F	F	o	F	o	F	F	F	o	o	F	o	p
1 a.	o	F	F	F	o	F	o	p	F	F	o	p	o	p	o
2 a.	o	F	F	F	o	F	o	F	F	F	o	o	p	p	o
1 a.	o	F	F	F	o	F	o	p	F	F	o	p	p	p	o
2 a.	o	F	F	F	o	F	o	p	F	F	o	p	F	p	p
2 a.	o	F	F	F	o	F	o	F	F	F	o	p	p	p	p
1 a.	o	F	F	F	o	F	o	F	F	F	o	F	o	p	p
2 a.	o	F	F	F	o	F	o	F	F	F	o	p	F	p	F
3 a.	o	F	F	F	o	F	o	F	F	F	o	p	F	F	F
2 a.	o	F	F	F	o	F	o	F	F	F	o	F	F	F	F
1 a.	o	F	F	F	o	F	o	F	F	F	p	F	F	F	F
1 a.	p	F	F	F	o	F	p	F	F	F	p	F	F	p	p
1 a.	p	F	F	F	p	F	p	F	F	F	p	F	F	p	F
1 a.	p	F	F	F	F	F	p	F	F	F	p	F	F	F	p
1 a.	p	F	F	F	F	F	o	p	F	F	F	F	F	F	F
2 a.	p	F	F	F	p	F	p	F	F	F	F	F	F	F	F
6 a.	p	F	F	F	F	F	F	F	F	F	F	F	F	F	F

the closure of the epiphyses of the long bones progresses in a quite regular order and that only a few of all these epiphyses are closed in juvenile life. Among 39 adult gibbons, in which the degree of dental attrition had been recorded as "0", there are only 2 with all epiphyses of the long bones closed and among 93 adult gibbons with moderate wear of the teeth (= "+") there are only 5 in which one of these epiphyses was still, at least partly, separate. This last epiphysis to close is invariably the proximal one of the humerus. It is interesting to note that the proximal epiphysis of the ulna, the last to develop an ossification center, is one of the first to become closed, whereas the proximal epiphysis of the humerus, which contains ossification centers already at birth, is the last one to close. It is evident, therefore, that the different epiphyses develop at widely varying rates and that there exists no correlation between the order of appearance of ossification centers and the sequence of epiphyseal union. The latter proceeds in the gibbon as follows, as far as the limb bones are concerned and referring only to completed union:

1. Humerus, distal
2. Medial epicondyle
3. Ulna, proximal
4. Small trochanter
5. Radius, proximal
6. Great trochanter
7. Head of femur
8. Phalanges
9. Tibia, distal
10. Fibula, distal
11. Metacarpals
12. Metatarsals
13. Fibula, proximal
14. Tibia, proximal
15. Femur, distal
16. Radius, distal
17. Ulna, distal
18. Humerus, proximal

This list represents the average condition. In individual cases this order can differ slightly, particularly regarding the detailed sequence of actually completed union of the epiphyses of tibia and fibula and of the head of the femur.

In figure 20 the order of epiphyseal union in the long bones of the gibbon are compared with this condition in the few other primates which have been studied in this respect so far. Such a comparison is facilitated by grouping the epiphyses according to regions, as has recently been emphasized by Washburn ('43). In all the primate series of figure 20 the epiphyses of the elbow region are the first to close, though closure of the proximal epiphysis of the radius is somewhat retarded in several types. The epiphyses of the hip region generally close as a second group and are followed by those of the ankle region as a third group. Knee, wrist and shoulder represent the fourth, fifth and sixth regions in the sequence of epiphyseal union, typical of Old World monkeys, gibbons and man. The great apes form an exception

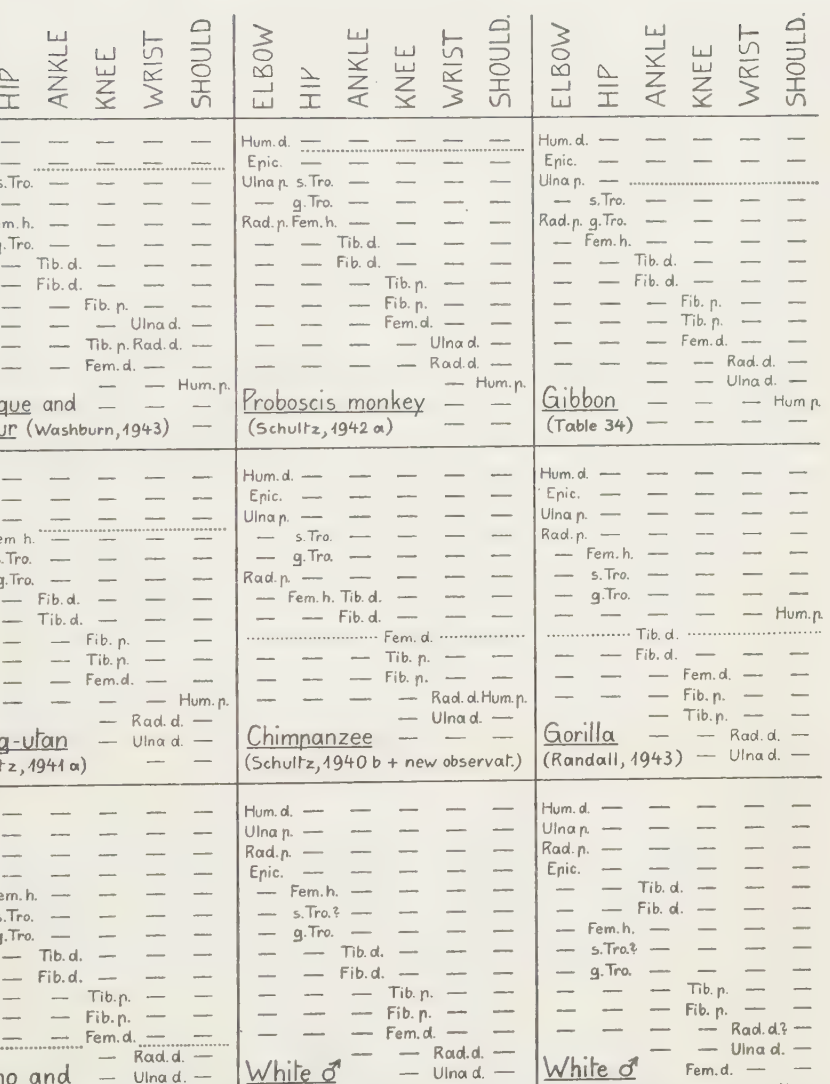

Fig. 20 The sequence of epiphyseal union in the long bones of primates. This sequence is arranged according to regions (listed on top) and begins in each of the nine squares in the upper left corner. The horizontal dotted lines indicate the approximate level at which all permanent teeth have become fully erupted and hence show the border between the juvenile and the adult period. These levels have been selected in all cases by the writer and are merely tentative for the five diagrams based upon data by other authors. Hum. = humerus; Epic. = medial epicondyle of humerus; Rad. = radius; Fem. = femur; s. Tro. = small trochanter; g. Tro. = great trochanter; Tib. = tibia; Fib. = fibula; h. = head; p. = proximal; d. = distal.

to this rule by manifesting a tendency for early closure of the epiphysis at the shoulder. The findings for man by Todd ('33) are not in agreement with the results of most other investigators (fig. 20). The writer can offer no explanation for this discrepancy, but believes that the average sequence, characteristic for man, is that obtained by Stewart ('34) for Eskimos and Indians which is identical with the sequence found by Flecker ('32) in male Whites and by Basu and Basu ('38) in female Bengalee. In female Whites this order differs in some details from that in males, according to Flecker and others, but not to a very significant extent. As indicated in figure 20, there exists no uniformity among primates in regard to the relation between the age of completion of the permanent dentition and the period of epiphyseal union in the long bones. In white man these epiphyses are all closed before the age of 20 years, i. e., before all the teeth have fully erupted. On the other

TABLE 35

Occurrence of a septal aperture in the humeri of gibbons (General Series I) at different ages.

AGE	SKELETONS EXAMINED	SEPTAL APERTURE			PERCENTAGE OF SKELETONS WITH APERTURES IN ONE OR BOTH HUMERI
		Right only	Left only	Both sides	
Infants	16	0	0	0	0
Juveniles I	7	0	0	0	0
Juveniles II	44	0	3	2	11
Adults ♀	99	5	9	11	25
Adults ♂	111	7	6	17	26

hand, most of these epiphyses are still separate at the age of completion of the dentition in macaques, langurs and gibbons. The gap between these extremes is bridged by the African great apes and also by Eskimos and Indians who, according to Stewart's data, frequently possess their third molars while the last few epiphyseal lines are still visible.

A septal aperture, or supratrochlear foramen, in the humerus develops in the gibbon only after the juvenile I period and exists unilaterally or bilaterally among adults in about one fourth of the cases, as shown by the data in table 35. With few exceptions this opening attains only a comparatively small size in gibbons. This aperture is relatively largest and most common among all primates in the orang-utan, having been found in about 85% of adults (Schultz, '41 a). In man the percentage frequency of this feature varies greatly with race and sex, amounting, e. g., to only 5 in male Whites and to 35 in female Negroes (Schultz, '37 a).

In this chapter on the skeletal development of the limbs it remains to be mentioned that the os centrale of the wrist was found to be solidly fused with the naviculare in 4 senile specimens [20] of the Chiengmai series (3 times bilaterally, 1 time unilaterally). The same condition has been observed by the writer in an old siamang and by several authors, whose findings have been collected in another paper (Schultz, '36), in a total of 5 adult gibbons. As is well known, the centrale develops regularly in the human embryo, but fuses, as a rule, with the naviculare during the third month of prenatal life. The African anthropoids are the only primates, besides man, which normally lack a free centrale in adult life. In these apes the centrale becomes fused with the naviculare in infantile life, according to evidence available so far (Schultz, '36). In the orang-utan (Schultz, '41 a), in the gibbon (as shown above), and some Old World monkeys (Washburn, '42) a corresponding fusion does occasionally take place, but only during adult life and particularly in old age. It can be concluded that the apparent lack of an os centrale in man, gorilla and chimpanzee is not as fundamental a distinction of these primates, as is commonly assumed, but represents merely a difference in the age at which this carpal element loses its independent existence. The tendency for the fusion between centrale and naviculare has been encountered in lower catarrhines and is clearly recognizable in the Asiatic anthropoids, though only late in life.

Skull

The growth changes and the variability of some of the most significant proportions of the gibbon skull have already been discussed in a previous chapter and still other cranial proportions have been dealt with in a former paper by the author ('33 a). Here it remains to record some volumetric observations on gibbon skulls. The size of the brain case, i. e., the cranial capacity, has been determined with rape seed in all skulls of the Chiengmai series. The averages and the ranges of variation of this capacity in the different age groups are shown in table 36. The cranial capacity varies individually very extensively and some infants can have larger values than some adults. A secondary sex difference in this absolute measurement does not appear until adult life and even then it is very small. That the cranial capacity is closely corre-

[20] To determine this fusion with certainty it is necessary to examine the carefully cleaned carpus in detail. This was possible in only 26 of the old H. lar. In this series the os centrale is fused in 15% of the cases. In all younger specimens of the Chiengmai series the centrale is separate, as far as this could be ascertained.

lated with the general body size not only in gibbons, but in all primates, has already been demonstrated by the author in another paper ('41 b).

According to the data in table 37, the cranial capacity (or the very similar brain weight) equals at birth between 40 and 63% of the final,

TABLE 36

*The cranial capacity (cc.) of H. lar (Chiengmai Series) at different ages. * = 2 of these specimens are very young infants with only their first few incisors and the third specimen is a full-term fetus of H. pileatus. The capacities of these 3 specimens were determined while the skulls were wet. ** = with nearly or entirely complete deciduous dentition.*

AGE	SPECIMENS	AVERAGE	RANGE
Newborns	3 *	64.2	52– 73
Infants **	9	86.2	68–102
Juveniles I	5	96.8	78–110
Juveniles II ♀	14	97.8	84–107
Juveniles II ♂	19	98.2	81–112
Adults ♀	85	100.9	82–116
Adults ♂	95	104.0	89–125

TABLE 37

The average cranial capacity of newborns, infants and juveniles in percentage of the arithmetic mean of the average capacities for adult females and adult males. The figures for the Rhesus monkey are based upon brain weight, instead of cranial capacity, and are calculated from data by Zuckerman and Fisher, except in the case of the newborns.[21] *The figures for gorilla are based upon data by Randall; in the case of the juveniles the mean has been used of the averages for females and for males. * = this figure, derived from the capacity of the smallest infant with incomplete first dentition, is undoubtedly somewhat larger than it would be in a really newborn specimen. The values for man are based upon data by Todd of which the averages for the following ages have been selected: Birth; 3 years (for infants); 12 years (for juveniles); and 20 years (for adults).*

PRIMATE	NEWBORN	INFANT.	JUVEN.
Rhesus monkey			
(Brain weight) Zuckerman and Fisher, '38	40.9	79.8	91.2
Gibbon			
(Table 36)	62.7	84.3	95.5
Orang-utan			
Schultz, '41 a	40.4	90.4	96.8
Chimpanzee			
Schultz, '40 b	45.7	84.5	99.7
Gorilla			
Randall, '43–'44	56.1 *	86.1	93.5
Man			
Todd, '33	23.3	81.7	96.7

[21] The brain weights of 3 newborn rhesus monkeys were determined by the writer; they average 36.2 g. From the detailed data by Zuckerman and Fisher the following average brain weights in rhesus monkeys have been obtained: 72.1 gm. for 8 infants, 82.4 gm. for 76 juveniles, 83.4 gm. for 22 adult females, and 97.2 gm. for 2 adult males.

adult capacity in the case of the non-human primates studied, whereas in man the corresponding percentage amounts to only 23. In infantile life the capacity has already reached from 80 to 90% of its size in adults and man does no longer differ markedly from the other primates in this respect. In juveniles the size of the skull cavity has attained, on an average, in all the series over 90% of its final size. From these figures it can also be concluded that the size of the brain increases very rapidly and intensively during the infantile period and very slowly during the remaining stages of growth. The gibbon is remarkable for having at birth a cranial capacity well over half the size in the adult.

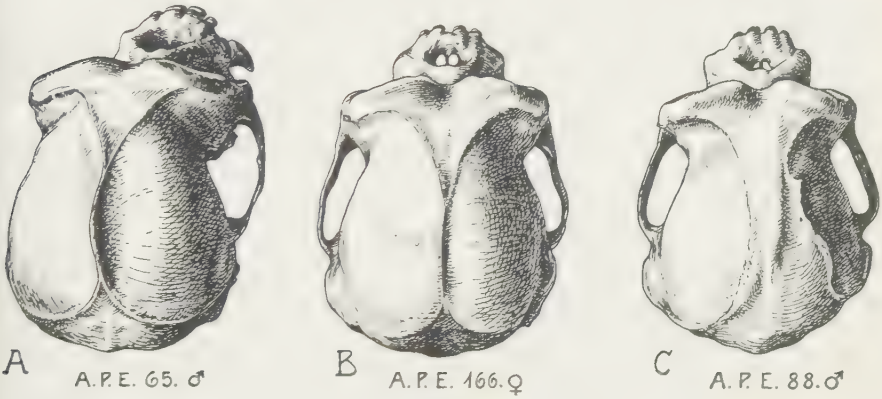

Fig. 21 Midsagittal crest in Hylobates lar, (A) male and (B) female, and (C) a malformed right temporal line in a male of the same species.

The outer surface of the brain case provides attachment area for the temporal muscles which increase enormously during growth. In adult gibbons with exceptionally small brain cases there exists at times insufficient surface for attachment of the temporal muscles on the frontal and parietal bones alone, in which case there develops a mid-sagittal crest, supplying the necessary, additional area for muscle insertion. Such crests exist in 3 female and 3 male adult gibbons of the Chiengmai series; they vary in greatest height between 1 and 4 mm. (fig. 21). In several other specimens of this series the right and left temporal lines have approached each other to the point of touching. All these cases are characterized by cranial capacities below average size and by palate lengths well above average. The larger the latter measurement, the larger are generally the temporal muscles and vice versa. That the temporal lines are closer together in gibbons with small brain cases (or

cranial capacities) than in those with large ones is evident from the following data: In 31 adult male H. lar with cranial capacities of 99 cc. or less the minimum width between the temporal lines averages 15.0 mm., but in 29 other adult male H. lar with capacities of 109 cc. or more the corresponding average is 19.7 mm. In the 27 adult female H. lar with the smallest capacities (96 cc. or less) the average width between the temporal lines equals 16.5 mm., but in the 27 adult females of the same series with the largest capacities (106 cc. and more) this width averages 20.0 mm.

The gibbon possesses very conspicuous orbits which are much larger in relation to body size than in the great apes and man. This relative size of the orbit in primates, including the gibbon, has already been discussed in a special study by the author ('40 a). Here it remains to record briefly the age changes in the size of the orbit and in its position. According to the data in table 38, the orbit of the gibbon has reached nearly one half its final size in infantile life. In human infants the orbit has already attained 60% of its size in adults, whereas in infantile orang-utans only 35%. During the juvenile II period the orbital volume amounts on an average to anywhere from 78 to 89% of its final size. In the oldest juveniles, lacking only their third molars, the orbit is practically as large as in adults (average difference in gibbons = 0.1 cc.). It is seen that the orbit grows in a manner similar to that of the brain, or cranial capacity, i. e., the most rapid increase occurs early in postnatal life. The growth curve of the orbit, however, is not as steep at first and as nearly level later on as is the typical growth curve of the cranial capacity. The volume of the orbit varies individually to a very marked degree. For instance, among the 95 adult male H. lar the range of variations extends from 8.3 to 11.0 cc. These variations are closely correlated with the variations in body weight (Schultz, '40 a, fig. 2) and the sex difference in the average orbital volume is explained fully by the corresponding difference in body size, not only in the gibbon, but in other primates as well.

During postnatal growth the orbit of the gibbon migrates from a position entirely underneath the brain case to one largely in front of it (fig. 22), exactly as happens in the great apes, but not in man (Schultz, '40 b, '41 a). This ontogenetic shift in the position of the orbit, together with the increase in size of this structure, produces the striking postorbital constriction of the skull, characteristic of all adult anthropoid apes, but lacking in infantile apes and in man at all stages of growth.

In the newborn gibbon the lambdoid and pteric fontanelles are completely closed, but the bregmatic and mastoid (or asteric) fontanelles are still wide open (fig. 22). In one gibbon infant with only its deciduous incisors erupted the bregmatic fontanelle has a maximum transverse diameter of 19 mm. and a maximum sagittal diameter of 24 mm.

TABLE 38

Age changes in the average volume of the orbit in the man-like apes and man and the averages for infants and for juveniles in percentage of the arithmetic mean of the averages for adult females and adult males. The averages for the juvenile gorillas are the means of the averages for females and for males, as given by Randall.

PRIMATE	INFANT.	JUV. I	JUV. II	ADULT ♀	ADULT ♂
Gibbon					
Chiengmai series					
Specimens	10	5	33	86	95
Average (cc.)	4.5	5.7	7.3	9.3	9.4
Percentage	*47.5*	*61.2*	*78.0*	..	..
Orang-utan					
Schultz, '41 a					
Specimens	10	13	21	46	53
Average (cc.)	8.1	13.9	18.8	20.4	26.4
Percentage	*34.6*	*59.4*	*80.4*	..	..
Chimpanzee					
Schultz, '40 a & new data					
Specimens	11	17	18	24	19
Average (cc.)	11.1	15.9	19.5	22.7	24.1
Percentage	*47.4*	*68.0*	*83.3*	..	..
Gorilla					
Randall, '43–'44					
Specimens	10	20	47	112	180
Average (cc.)	13.7	21.5	28.9	31.3	40.7
Percentage	*38.1*	*59.7*	*80.3*	..	..
Man					
Schultz, '40 a & new data					
Specimens	13	3	3	42	88
Average (cc.)	14.1	17.9	20.8	21.6	25.1
Percentage	*60.5*	*76.8*	*89.3*	..	..

In another specimen, in which the first lower molars have appeared besides all incisors, the diameters of this fontanelle equal 10 and 14 mm. respectively. The bregmatic fontanelle is still wide open at birth not only in the gibbon, but also in the proboscis monkey (Schultz, '42 a) and in man. In contrast to this, the bregmatic fontanelle is either dimi

nutive in size or else entirely closed at birth in macaques, orang-utans and chimpanzees (Schultz, '37 b, '40 b, '41 a).

All fontanelles can at times become closed with the aid of atypical, single, or multiple ossicles developing in the fontanelles themselves. These occurrences are described in the chapter on developmental abnormalities. The pteric fontanelles are closed by the surrounding cranial bones in an individually varying manner. Among 136 gibbon skulls, in which the sutures of the pteric region had not become obliterated, the alisphenoid meets the parietal (r. & l.) in 91 cases (= 67%),

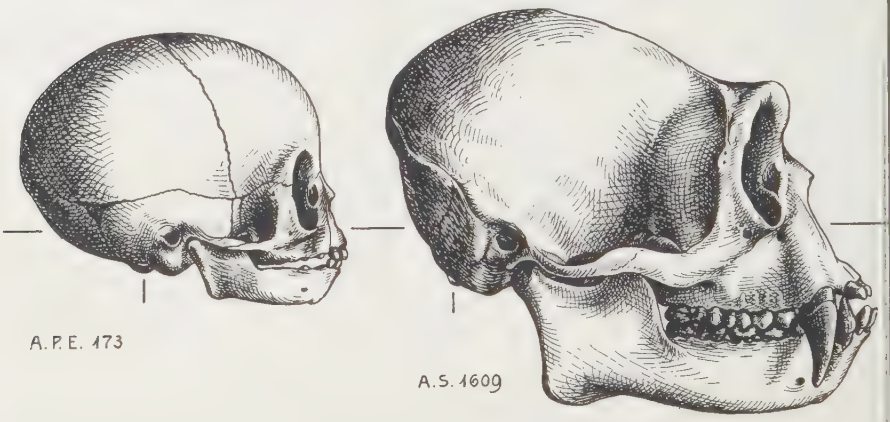

Fig. 22 Skulls of a very young infantile and of an adult Hylobates lar, posed in ear — eye horizon and both reduced the same amount. The small perpendicular lines indicate the location of the center of the occipital condyles.

the temporal meets the frontal (r. & l.) in 35 cases (= 26%), and in the remaining 10 cases (= 7%) one of these conditions exists on one side and the other condition on the opposite side. In 13 of these specimens the temporal meets not only the frontal, but also the zygomatic bone (4 times unilaterally and 9 times bilaterally). Ashley-Montagu ('33) found a spheno-parietal contact in 84%, a fronto-temporal contact in 11%, and asymmetrical articulations in 5% of 83 gibbons examined by him. These percentages do not agree very closely with those of the writer.[22]

[22] This puzzling discrepancy is not due to species differences. Ashley-Montagu's series contains 33 H. lar of which 94% have the spheno-parietal type of pterion and 6% the fronto-temporal type. Among the writer's 100 H. lar (Chiengmai series) the former type exists in 67 cases and the latter in 25 cases, a distribution which is practically the same as that in the writer's General series.

In the gibbon the two halves of the mandible become firmly united immediately after birth. The temporo-mastoid sutures close, as a rule, also at this time, but can persist occasionally until the deciduous dentition is nearly completed. The interfrontal or metopic suture is normally obliterated in gibbons possessing at least the majority of their deciduous teeth. As far as the writer has been able to ascertain, this suture closes in the gibbon slightly later than in the orang-utan, but earlier than in the macque, proboscis monkey, chimpanzee, and man. The next sutures of the gibbon skull to close are those between the different occipital elements. The basioccipital, the lateral occipitals and the occipital squama are still entirely separate in 14 gibbon infants (12 with complete first dentition) of the General series II. In 9 other infants of the same series the lateral and squamous portions have become partly fused, and the basioccipital is separate. Among 13 gibbons of the juvenile I period all occipital parts are separate in only 1 specimen and all parts have become fused in 10 specimens. In the remaining 2 cases the basioccipital is free, but the lateral and squamous parts have started to unite. Among a total of 38 gibbons of the first half of the juvenile II period (before eruption of premolars) there are only 2 in which the basioccipital is still free (and squamous occipital fused) and 7 others in which the lateral ends of the sutures between the squamous and lateral occipitals have remained open. In the 30 remaining cases, as well as in all older juveniles, the occipital elements have become completely united. These observations can be summarized by stating that in the gibbon the squamous occipital generally begins to fuse with the lateral occipitals (at the medial ends of the sutures) very soon after the first dentition has been completed, but this fusion is not finished in all cases until the permanent incisors have appeared (= juv. II period). Fusion between the basioccipital and the lateral parts takes place, as a rule, during the juvenile I period. This agrees quite closely with the conditions in proboscis monkeys, orang-utans, chimpanzees and man, according to the writer's previous investigations.

The relation between dental age and the process of ectocranial obliteration of some other sutures in gibbon skulls is shown in the tables 39 and 40. The sutures separating the premaxillary from the maxillary bones on the facial aspect of the skull begin their closure in the lower half of the suture. This suture can become closed late in juvenile life, but generally it disappears not until early in the adult period and occasionally it can remain open even in specimens with a moderate degree of dental attrition. Ehrhardt ('31) has found this suture entirely closed in no infants, but in 8% of young juveniles, 22% of older juve-

niles, 79% of adults, and 99% of seniles in a series of gibbons (H. con color) totalling 222 specimens. This author concludes that the pre maxillary sutures close earlier in gibbons than in orang-utans and earlier in females than in males. According to Ashley-Montagu ('35) the premaxillary sutures have become obliterated in 7% of infants 36% of juveniles, 93% of adults without wear of teeth, and 96% of adults with moderate wear of teeth in a total series of 141 gibbons

TABLE 39

Percentages of specimens with partly and with entirely closed premaxillary, internasal, trans verse and sagittal palatine, and occipito-mastoid sutures among gibbons (General Series I) i different age groups. These sutures are entirely open in all gibbons of the infantile and ju venile I periods.

AGE	SPECIMENS	PREMAXILLARY		INTERNASAL		PALATINE		OCCIPITO-MASTOI	
		Lower part closed	Entirely closed	Partly closed	Entirely closed	Trsv. closed	Trsv. & sag. closed	Upper part closed	Entirel closed
Juveniles II	44	11	7	5	2	0	0	0	0
Adults with no wear of teeth	39	15	59	10	31	0	3	3	0
Adults with moderate wear of teeth	93	5	91	3	88	11	63	20	14
Adults with very marked wear of teeth	79	0	100	3	97	0	99	62	27

TABLE 40

Percentages of specimens with partly and with entirely closed sagittal, basilary, lambdoi and coronal sutures among adult gibbons (General Series I) grouped according to the degre of wear of the teeth. These sutures are entirely open in all infantile and juvenile gibbon examined.

AGE	SPECIMENS	SAGITTAL		BASILARY		LAMBDOID		CORONAL	
		Partly closed	Entirely closed	Partly closed	Entirely closed	Partly closed	Entirely closed	Partly closed	Entirel closed
Adults with no wear of teeth	39	8	28	5	28	15	18	13	8
Adults with moderate wear of teeth	93	3	93	2	93	4	91	9	84
Adults with very marked wear of teeth	79	0	100	1	99	0	100	0	100

Very few of the corresponding percentages of Ehrhardt, Ashley-Montagu and the writer (table 39) show close agreement, particularly regarding the earlier age groups. These discrepancies demonstrate the remarkable variability in the age of closure of these sutures. Based upon the writer's former ('40 b, '41 a) and present observations it is concluded that in general the facial part of the premaxillary suture closes later in gibbons than in orang-utans and in chimpanzees. It is a well established fact that in man these sutures close very much earlier than in the apes, namely in prenatal life.

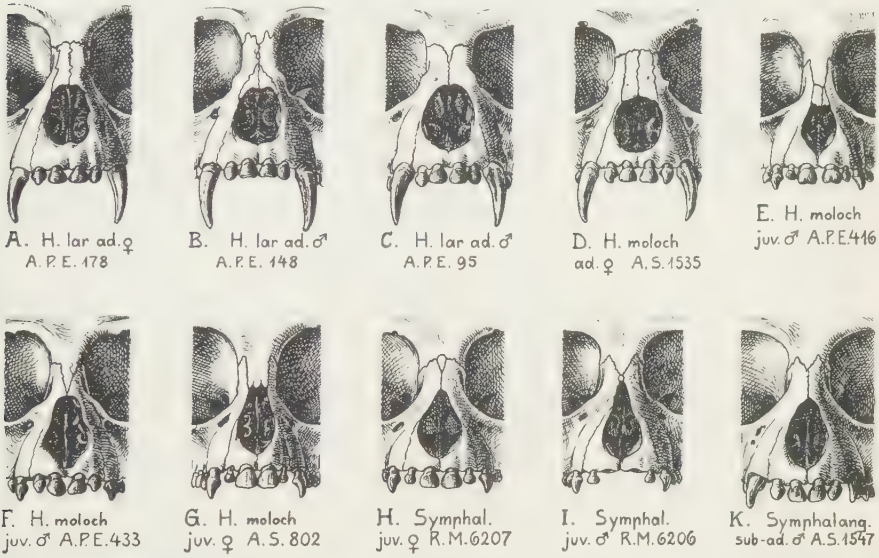

Fig. 23 Variations of the nasal bones and congenital lack of these bones in gibbons (A to G) and siamangs (H to K).

The internasal suture of gibbons becomes closed, as a rule, early in adult life (table 39). In the orang-utan this suture closes normally during the first part of infantile life (Schultz, '41 a) and in chimpanzees and macaques even before birth (Schultz, '37 b, '40 b). In man the nasal bones fuse very rarely, even among old individuals. The nasal bones are extremely variable in size and shape among all gibbons and siamangs, as is shown by the examples in figure 23. In a considerable number of cases the nasal bones are rudimentary or even completely absent and this can occur within the same local series that contains specimens with very large nasal bones. For instance, the cases of H. lar, shown in figure 23, are from the Angka series alone and the

cases of H. moloch are all from British North Borneo. In the orang-utan there also exists this tendency to suppress the nasal bones in sporadic cases (Schultz, '41 a).

The sutures of the palate generally close in gibbons not until the completed dentition shows a moderate degree of attrition. The transverse palatine suture is obliterated slightly sooner than the sagittal one (table 39).

Closure of the main sutures of the cranial vault and base occurs in gibbons normally not before the adult stage has been reached. As shown by table 40, the sagittal and basilary sutures close at practically the same time. The lambdoid suture is obliterated somewhat later and

TABLE 41

The weight of the skull (gm.) in adult gibbons with no or little wear of the teeth and in senile gibbons (Chiengmai Series).

SEX	AGE	SPECIMENS	AVERAGE	RANGE
Female	Adult	20	49.7	43.0–62.5
	Senile	15	42.5	36.5–50.5
Male	Adult	20	54.9	45.0–72.0
	Senile	15	49.4	37.5–57.0

the coronal suture is the last of these four sutures to close. In gibbons with marked wear of the teeth all sutures have disappeared, as a rule, except the lower parts of the occipito-mastoid sutures (table 39) and, occasionally, traces of the diagonal sutures in the zygomatic arches as well as of the naso-maxillary sutures. Comparisons with other primates regarding these conditions are best postponed for a later, special study.

In this chapter on age changes in the gibbon skull it remains to be mentioned that after nearly all sutures have disappeared and the dentition has become much worn the weight of the skull often becomes considerably reduced. This is shown by the data in table 41 which represent the weights of uninjured skulls, selected at random from a larger series, and all prepared by strictly uniform methods (cold water maceration for constant period). It is seen first of all that the skull weight can vary individually to a degree quite in accordance with the high variability of the total body weight. On an average, the skull is considerably heavier in males than in females of the same age group. In both sexes the skull becomes significantly lighter in old age, the aver-

ages and ranges of variations shifting to lower values than exist in adults which had died in the prime of life. This bony atrophy, typical of senility, leads in extreme cases to irregular perforations of the thinnest cranial parts, such as the posterior walls of the orbits and the upper walls of the mastoid cells, as shown by the examples in figure 18 (C, D). A corresponding senile atrophy has been observed in several other skeletal structures, particularly the ilium and the scapula, as has been mentioned in previous chapters.

DEVELOPMENTAL ABNORMALITIES

This study has so far dealt chiefly with the normal growth and development of the gibbon, considering also the individual deviations from average conditions. In this chapter will be recorded all occurrences of abnormal development encountered in the available gibbon material. At times it is difficult to distinguish between congenital, localized abnormalities and normal, but extreme variations. For example, a cervical rib in a primate must theoretically be regarded as the result of abnormal development, but the lack of a rib on the last thoracic vertebra is correctly interpreted as one extreme of a series of normal variations in a species, such as the gibbon, showing all degrees of reduction in size of the last ribs. The third molars of some primates vary enormously through all stages of degeneration to an extreme, represented by total lack. Whether the absence of such molars should properly be listed under "developmental abnormalities" or under "variations", is a debatable question. There is no precise border between normal and abnormal that can be recognized and applied consistently, hence it is unavoidable that one can make only an arbitrary selection of conditions to be labelled "developmental abnormalities." It is the chief purpose of this chapter to deal with the frequency of abnormalities in a population of wild apes, rather than to dwell on the details of the conditions themselves. The literature of teratology is based largely on findings in modern, civilized man. The comparatively few reports on abnormalities in wild animals are mostly bare case histories without reference to the numerical proportion between the malformed and the normal specimens observed. Thus, there arose the prevalent and unjustified idea that developmental defects appear extremely rarely under natural conditions in the wild and become rapidly eliminated again in the struggle for survival.

The forms and frequencies of developmental defects in the dentitions of gibbons have already been discussed in a previous chapter. A few anomalies from the gibbon material of this study have been published

in other papers, namely the occurrence of an accessory nipple in an adult H. lar of the Angka series,[23] reported by Coolidge ('43), and the existence of unilateral cryptorchism in two H. moloch and one H. lar (=5% of 62 wild male gibbons autopsied), described by the writer ('38 c). Another anomaly, found among the freshly killed specimens, is recorded here: An adult female H. lar of the Angka series possessed an umbilical hernia which showed on the outer body as a circular elevation, 6 mm. high and 18 mm. in diameter. There was a corresponding gap, 9 mm. wide, in the linea alba with protrusion of the peritoneum. It seems most likely that this represents a congenital hernia and, as far as can be ascertained, it is the first such case encountered in a non-human primate.

Developmental abnormalities of the vertebrae of gibbons are surprisingly common. Some of these have already been referred to in a previous chapter dealing with the spinal column. The atlas is particularly prone to deviate from its normal development. The Chiengmai series contains one specimen in which the atlas is extensively fused with the occiput and the third and fourth vertebrae are solidly united (fig. 24, A). Since there is no sign whatsoever of any disease process and since these particular vertebrae have somewhat reduced cephalocaudal diameters, there can be no doubt that these fusions existed already in prenatal life. Cases of what should really be called incomplete separation between atlas and occiput have been recorded many times in man, but in other primates this abnormality is exceedingly rare. Randall ('43–'44) mentions this condition as occurring in 1 wild gorilla among the 456 gorilla skulls examined by him. In no less than 7 specimens of the Chiengmai series the dorsal arch of the atlas is incompletely formed, exactly as shown by the example B in figure 24. This really represents a condition known as localized spina bifida occulta, which can occur in any of the vertebrae. It is fairly common in the human atlas and has been recorded, also for the atlas, in a proboscis monkey and, for the first 3 sacral vertebrae, in an orang-utan (Schultz, '41 a, '42 a). In 1 gibbon the dorsal arch of the atlas is entirely separate (fig. 24, C), hence must have been ossified from a special center, rather than in the normal manner as bony outgrowths from the centers in the lateral masses. In 4 other gibbons of the same series the ventral arch of the atlas is incompletely formed, as shown by the example D in figure 24. In still another gibbon this ventral arch is entirely separate (E), though the animal is fully adult. The ventral arch develops from one or,

[23] It is noteworthy that this specimen (A. P. E. 158) also possesses a supernumerary digit growing from the left second finger.

more rarely, two ossification centers and normally fuses with the lateral masses not later than the beginning of the juvenile II period of gibbons. The Chiengmai series contains 3 additional cases in which both, the dorsal and the ventral arches are incompletely developed (fig. 24, F). Finally, there are 2 other specimens of H. lar with a practically total lack of both arches (G). The last example, shown in figure 24, illustrates the abnormal lack of fusion between part of the dens epistrophei and the second vertebra. Since this dens is derived from the

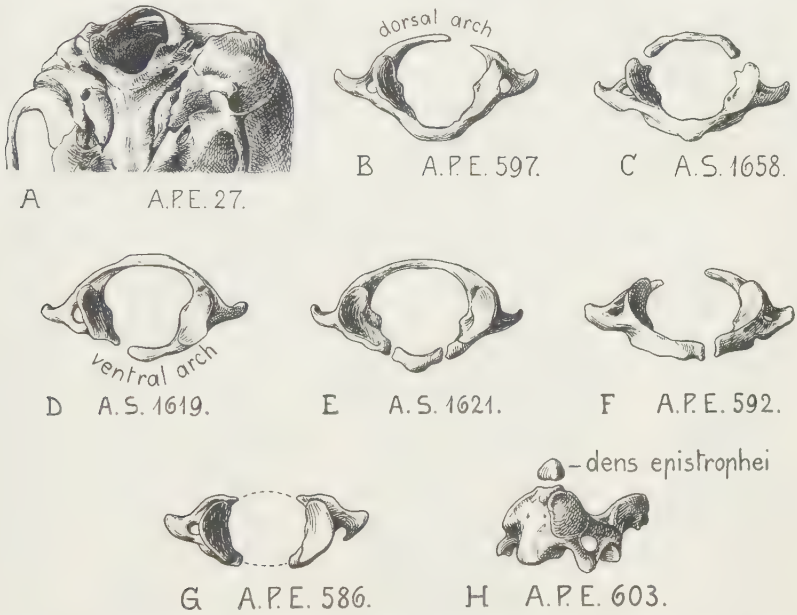

Fig. 24 Developmental abnormalities of the atlas in fully adult gibbons of the Chiengmai series. A = fusion between atlas and occiput; B and C = incompletely formed dorsal arch; D and E = incompletely formed ventral arch; F and G = incompletely formed dorsal and ventral arches; H = lack of fusion of dens epistrophei. B to G = cranial view of atlas with ventral arch below.

body of the first vertebra, it is in order to list it among the anomalies of the atlas. The latter have been found in 20 out of the 233 skeletons of the Chiengmai series, i. e., with the amazing frequency of 8.6% of the cases. Incidentally, 16 fo these anomalous gibbons are males and only 4 females.

Of other vertebrae which had developed abnormally the following are specially noteworthy: Anywhere from 2 to 6 cervical vertebrae are fused and at the same time appear to be stunted in height in 5 H. lar

from Chiengmai (not including cases of fusion, evidently due to disease processes). Two of these cases are illustrated in figure 25 (L, M). Precisely the same type of non-pathological fusion among cervical vertebrae is not infrequently seen in man (e. g., Pan, '32). In man, as in the gibbon, this intervertebral fusion is much more common in the cervical region than in the other spinal portions. The term "fusion", though customary, is misleading in this connection since this condition is due to incomplete segmental cleavage.

Figure 25 shows a remarkable instance (K) of asymmetrical formation of thoracic vertebrae which does not appear to be of a pathological nature. This specimen is a young adult with its teeth very little worn. There is another case of scoliosis of the thoracic portion of the spine in a gibbon from Chiengmai, but this specimen is senile and the diseased bodies of many of its vertebrae show peripheral exostoses and deep central erosion. In one gibbon the third thoracic vertebra is incompletely formed, the right half of the dorsal arch having failed to develop and the neck of the right, third rib is abnormally small (fig. 14, I). The coccygeal vertebrae of gibbons are frequently malformed. One such case is shown in figure 25 (N). In two instances the last coccygeal vertebra is represented by two ossicles lying side by side and in another specimen this last vertebra is forked. In many cases the terminal piece of the coccyx is long, slender and most likely composed of at least two vertebral segments which had become fused at an early stage.

Instances of abnormally developed ribs are shown in figure 14 and require no further comment. Besides the cases illustrated there is one specimen with bifurcation of a rib, similar to, but not as extreme as the condition shown in example K. Of the last pair of ribs one or both ribs are ankylosed with the last thoracic vertebra in 8 gibbons.

Among the abnormalities of the limbs there is one most unusual case (of the Angka series) in which the left upper extremity was lacking distal to the middle of the upper arm. The proximal stump of this extremity contained only skin, some thin muscular tissue, fine blood vessels and nerves, and the proximal part of the humerus, all very much reduced in size, except the caput humeri (figure 25, H). This rudimentary limb was covered with hair throughout and no scar tissue could be detected. The writer is convinced that this is a case of incomplete development of an entire extremity. Incidentally, this animal was seen to climb with apparently unimpaired dexterity and was as well nourished as most other, normal gibbons. In another adult of the Chiengmai series the right radius is incompletely formed, part of the shaft being lacking (fig. 25, G). Conditions such as those described here are known

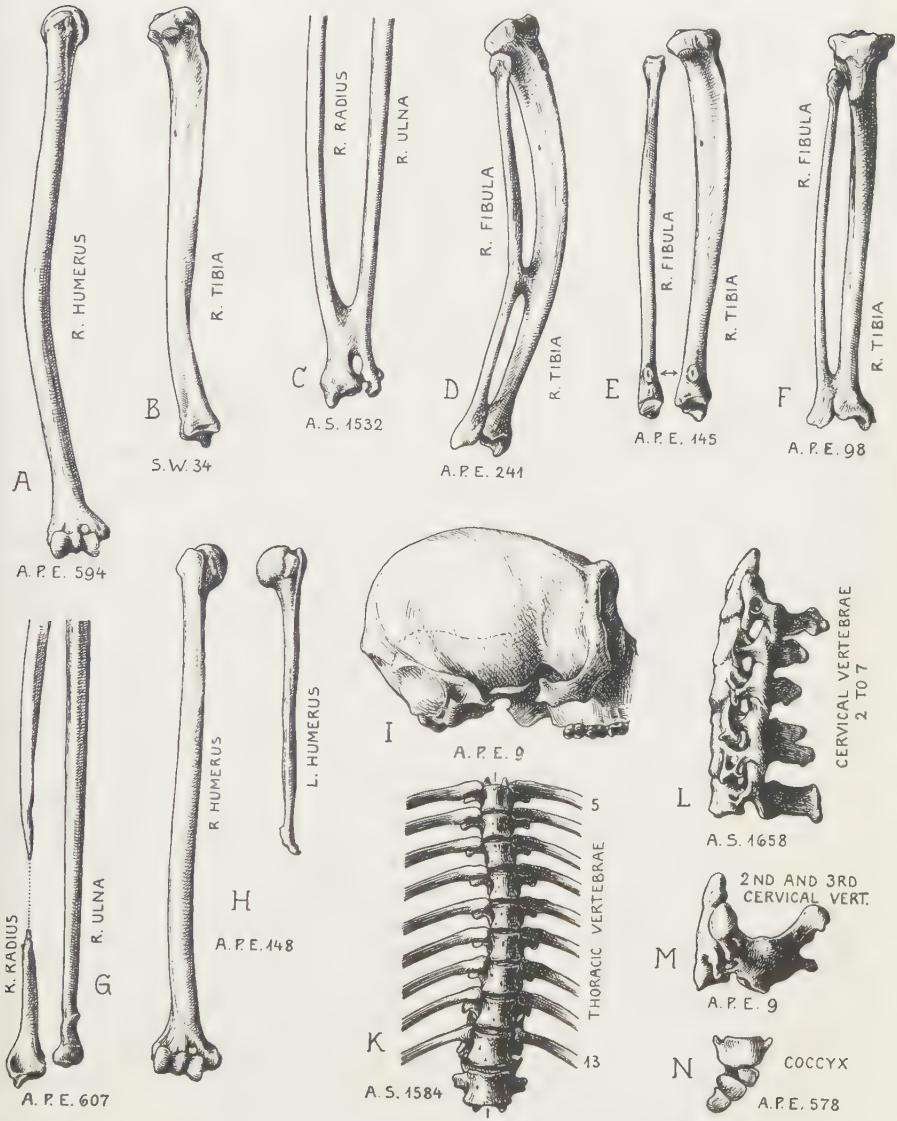

Fig. 25 Developmental abnormalities of the limb bones, zygomatic arch and vertebrae in gibbons. All specimens are adult H. lar of the Chiengmai series, except D, which is an adult H. moloch, and N, which is a juvenile H. lar. A and B = abnormally curved long bones; C and D = abnormal fusion between long bones; E and F = abnormal contact between tibia and fibula; G = incompletely formed radius; H = normal right and abnormal left humerus of "one-armed" gibbon; I = incomplete zygomatic arch; K = scoliotic thoracic spine; L = fused cervical vertebrae II to VII; M = fused cervical vertebrae II and III; N = asymmetrically formed occygeal vertebra.

to occur in man and to be present already in prenatal life, being undoubted developmental defects (e. g., Unterrichter, '34).

In a number of gibbon skeletons have been encountered abnormal bony contacts or connections between radius and ulna and between tibia and fibula (fig. 25, C to F). Since there are no symptoms of a pathological nature, no other cause for these conditions seems plausible than that of aberrant development. Finally, it is mentioned here that in a very considerable number of wild gibbons one or another, or even several of the long bones of the limbs have been found to be abnormally curved, as shown by the examples in figure 25, A, B and D. The humerus, e. g., is bent, more or less as shown by example A, in 11 gibbons of the Chiengmai series (in 5 cases r. & l. humeri). Normally the humerus of gibbons is straight as a ramrod (see r. humerus of H). Such cases are not old "greenstick" fractures and there is no sign of rickets in x-ray photographs of some of these cases. This abnormal curvature of the long bones of wild gibbons is certainly not comparable to the pathological bending of long bones which the writer has frequently seen in the skeletons of captive monkeys which had suffered from malnutrition.

Among all developmental abnormalities those affecting the fingers and toes are probably the most common ones and certainly have produced the most extensive literature which dates back to antiquity.[24] Polydactyly, in particular, has been studieed by innumerable authors who have proposed widely varying explanations for its origin. This type of defect is well known to occur with great frequency not only in man, but also among domestic animals, especially swine, cats, horses, and fowl (e. g., Prentiss, '03). Only a few records have been published on the existence of developmental abnormalities in the hands and feet of simian primates. Friedlowsky (1870) described in detail the hand of a macaque in which the fingers II to V are congenitally malformed. Bolau (1877) has published a brief report on polydactyly in an orang-utan which possesses on both hands a supernumerary digit sprouting from the fifth basal phalanx. A paper by Goldschmidt ('10) deals with a "cleft-footed" chimpanzee in which the toes II to IV of one foot are almost entirely lacking, having failed to develop. Pearson ('31) has contributed a well illustrated report on the occurrence of the teratological condition, known as "lobster claw", in a chimpanzee and in a macaque. These profound malformations, shown in figure 26, exist in

[24] The occurrence of a sixth digit on each hand and each foot in a human giant is recorded in the Bible (2 Sam. XXI. 20). Suetonius mentions that Julius Caesar's horse had hoofs cleft like toes. Pliny refers to 2 sisters with 6 fingers on each hand and to a polydactylous poet, named appropriately Sedigitus.

one hand of the chimpanzee and, in varying degree including syndactyly, in both hands and both feet of the macaque. The writer ('42 a), finally, has briefly discussed cases of supernumerary digits in a proboscis monkey, a langur and three macaques and incomplete development of digits in one of the last mentioned three as well as in a fourth macaque. To these records may here be added the case of abnormal development in the hand of a mandrill, shown in figure 26. Only the left

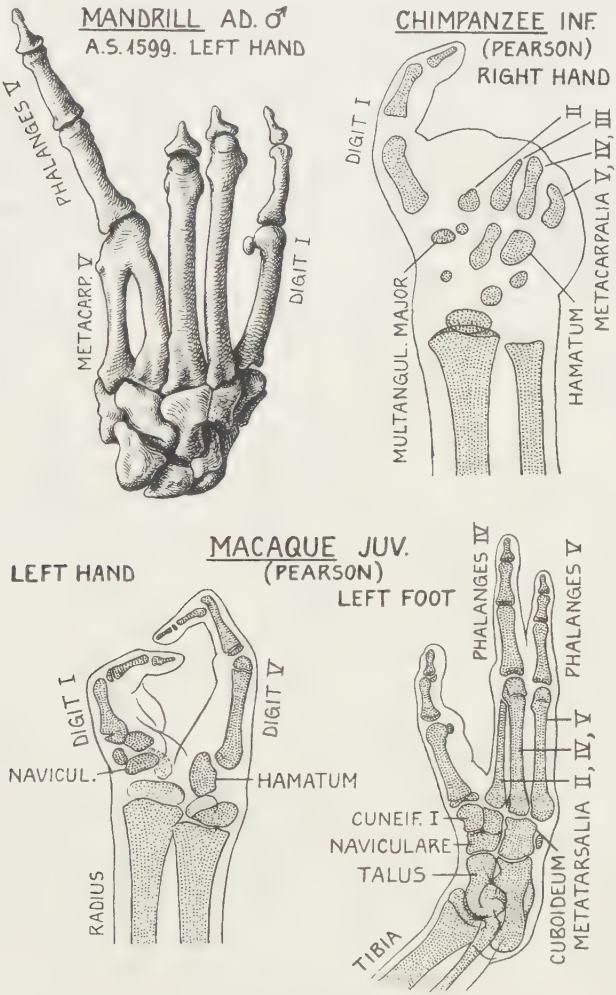

Fig. 26 Developmental defects in the hand of a mandrill (Papio sphinx) in the author's collection, in the hand of a chimpanzee and in the hand and foot of a macaque (Macaca mulatta). The latter 2 cases after Pearson ('31).

fingers I and V are fully developed in this animal,[25] the phalanges of the fourth finger are entirely lacking and those of the second and third fingers are represented merely by vestiges, and the fourth and fifth metacarpals are fused at both ends, the fourth also forming an extensive, abnormal, proximal contact with the third metacarpal bone. The latter conditions correspond to the abnormal fusions in long bones, described above and shown in figure 25 (C to F). Finally, this list is completed by referring to a recently acquired, adult, male chimpanzee with abnormally short right and left middle fingers. On both hands it is the basal phalanx of digit III which is affected, the right one being stunted in size only, whereas the left one lacks the major part of the shaft and the proximal phalangeal stump bears two abnormal, parallel, volar processes. Such incomplete development of the diaphysis of a basal phalanx exists also in one of the above mentioned macaques and in a gibbon (fig. 27, S) and corresponds to the condition of the radius shown in figure 25 (G).

Among the gibbons, examined for this study, digital malformations are amazingly common and varied. Examples of these congenital defects are shown in figure 27. In the Angka series of 113 gibbons the following defects on hands and feet exist: Supernumerary digits in 10 specimens, 6 times on feet and 4 times on hands. These abnormal digits vary in size from small, grape-like appendages without any vestige of bone to large, well formed structures with nails and phalanges; they branch from normal digits at either the basal, middle, or terminal segments and on the volar or lateral sides, but never on the dorsal side. Congenital reductions in the digits exist in 10 gibbons of the Angka

Fig. 27 Developmental defects in the hands and feet of gibbons of the Chiengmai series. A = accessory digits on toes III and IV and incompletely formed toe III; B = accessory digits on toes III, IV and V; C = accessory digits on fingers III and V and incompletely formed finger III; D = accessory digits on toes I and III, toes IV and V stunted; E = accessory digit on incompletely formed toe IV and partial fusion between II and III; F = accessory digit on finger I; G = accessory digit on finger IV; H = accessory digit on finger II; I = incompletely formed and fused toes II and III; K = incompletely formed toe V and finger I in one animal; L = fused metacarpalia II and III and accessory metacarpale and incompletely formed finger I on opposite hand in one animal; M = fused metacarpalia II and III (with abnormal bony prong) and incompletely formed finger V; N = incompletely formed fingers IV and V; O = abnormal contact between metacarpalia IV and V; P = fusion between metacarpalia II and III; Q = abnormal contact between metacarpalia III and IV and fusion between IV and V with free distal end of metacarpale V; R = forking of metacarpale I; S = incompletely formed basal phalanx II, ankylosis between basal and middle phalanges II and abnormally short middle phalanx V.

[25] The writer had known this mandrill ever since its early infancy. The abnormality of the hand had remained unchanged during the more than 6 years the animal had lived in the municipal zoo of Baltimore.

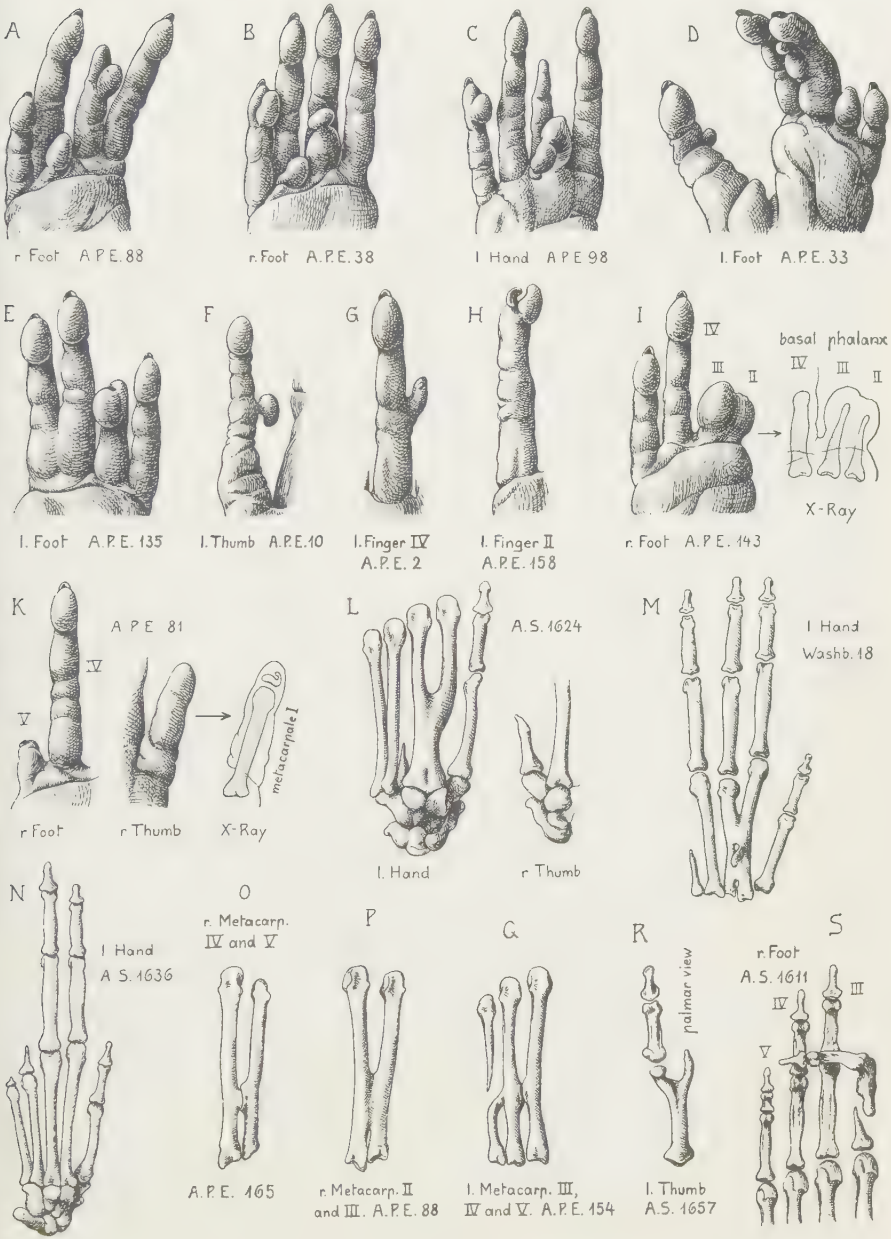
A
r. Foot A.P.E. 88
B
r. Foot A.P.E. 38
C
l. Hand A.P.E. 98
D
l. Foot A.P.E. 33
E
l. Foot A.P.E. 135
F
l. Thumb A.P.E. 10
G
l. Finger IV
A.P.E. 2
H
l. Finger II
A.P.E. 158
I
IV
III
II
basal phalanx
IV
III
II
X-Ray
r. Foot A.P.E. 143
K
A.P.E. 81
IV
V
r. Foot
r. Thumb
X-Ray
metacarpale I
L
A.S. 1624
l. Hand
r. Thumb
M
l. Hand
Washb. 18
N
l. Hand
A.S. 1636
O
r. Metacarp.
IV and V
A.P.E. 165
P
r. Metacarp. II
and III. A.P.E. 88
Q
l. Metacarp. III,
IV and V. A.P.E. 154
R
palmar view
l. Thumb
A.S. 1657
S
r. Foot
A.S. 1611
IV
III
V

Figure 27

series, 4 of which also bear supernumerary digits. These reductions show widely varying degrees of which only the more marked ones are considered here. All the phalanges of a finger or a toe can fail to develop (fig. 27, L, M) or only some of the phalanges (D, E, I, K, N). That such reductions are congenital malformations and not due to some accidental loss, is evident, e. g., from the fact that in many instances the terminal digital segment with its nail is present, while the middle and basal segments are stunted or lacking (e. g., D, K). Furthermore, at times such reduced digits are also abnormally fused, or at least webbed (I). Additional malformations among the hands and feet of the Angka gibbons consist in fusion between bones, occurring in 4 specimens, 2 of which possess some of the previously listed anomalies (e. g., the conditions shown in A and P exist in one and the same gibbon). In 3 of these cases the metacarpals IV and V are abnormally fused and in the fourth case the second and third metacarpals are partly fused. In one of the former the middle and terminal phalanges V are also fused and in another (Q) there is also an abnormal contact between the metacarpals III and IV, the distal portion of the fifth metacarpal is "free", and the same specimen has an accessory digit on the right fourth toe. Altogether there are 15 feet and 10 hands with digital anomalies among these gibbons. In man it is generally the hand which is more frequently affected than the foot.

As shown above, the Angka series contains a total of 18 gibbons, or 16% of all specimens, with at least one, and often several, marked digital malformations. In the Chiengmai series, without the Angka material, there are 120 gibbon skeletons of which 11, or 9%, show each at least one marked bony anomaly on fingers or toes. If these specimens could have been examined first in the flesh, as those of the Angka series, additional cases would undoubtedly have been found. As mentioned before, some accessory digits contain no bone and leave no trace on the skeleton. Some of the above 11 cases are shown in figure 27 (L, M, N, R, S). They contain an instance of forking of the distal end of the first metacarpal bone and 2 cases of extensive metacarpal fusion, or syndactylism, both associated with incomplete formation of other digits and one also with a vestigial supernumerary digit (L). In 6 of these cases the basal phalanges of one or another finger bear on their volar sides abnormal bony processes of considerable size, well shaped and smooth in texture, altogether different from pathological exostoses. Whether or not they belonged to the base of accessory digits must remain undecided. In the gibbon material not yet referred to (54 complete skeletons of different species) digital anomalies have been encountered

in only 2 cases, namely a H. moloch with extensively fused metacarpalia IV and V and a H. agilis with 2 supernumerary toes on the left foot and with the middle toe of the same foot abnormally shortened.

All the digital abnormalities of monkeys and apes, listed above, have been found also in man. From the great many published reports on the corresponding conditions in human beings it has become well established that many of these malformations are not restricted to the outer form and the skeleton, but involve the soft parts as well (e. g., Ballowitz, '04), and that there exists a hereditary tendency for the occurrence of many types of these anomalies (e. g., Müller, '37). In man, however, these malformations are not nearly as common as in the gibbons of the Angka series. The percentage frequency for the latter is 16, an amazingly high value. In a very much inbred strain of mice Fortuyn ('39) found polydactylism in 12% of males and 18% of females. One might be justified in assuming that the gibbon population of Doi Angka also is inbred. In the remainder of the Chiengmai series digital anomalies occur in at least 9% of the cases. Among 152 macaques such malformations were found in only 3% of the specimens, among 51 proboscis monkeys in 2% and among 83 langurs in 1% (Schultz, '42 a). Considering these comparative data, it can be concluded that the tendency for abnormal development of digits is quite exceptionally marked in Hylobates lar, at least in those from the mountainous region near Chiengmai. It is remarkable that this tendency is not limited to any particular category of anomalies, but is manifested by a very wide range of different developmental irregularities, indicating general instability in the early development of the distal portions of the limbs.

The developmental abnormalities of the skull in gibbons are numerous and varied; they will be briefly recorded in the remaining part of this chapter and are illustrated by figure 28.

A cranio-pharyngeal canal, penetrating the basisphenoid bone, is a normal feature early in intrauterine life, but persists abnormally to adult life in only 0.5% of human beings (Schultz, '16). Among the Hylobatidae this canal remains open throughout life with very much higher frequency, as shown by the data in table 42. In the combined series of adult gibbons the canal was found in 30% of the cases. Among adult orang-utans the canal exists in 12% and among adult chimpanzees in 74% of the cases (Schultz, 41 a). In the Cercopithecinae this canal occurs in less than 1%, whereas in the Semnopithecinae, the other subfamily of lower catarrhines, in 14% of the cases (Schultz, '16), with the exception of the genus Nasalis in which a persistent canal is unknown (Schultz, '42 a). In all primates the canal is encountered more

TABLE 42

The percentage frequency of the persisting cranio-pharyngeal canal among 509 skulls of Hylobatidae (General Series II and data from Schultz, '33 a). In the entire series the canal exists in 59% of the 27 infants, in 52% of the 77 juveniles and in 30% of the 405 adults.

SPECIES	AGE	SPECIMENS	PER CENT OF CASES WITH CANAL
H. lar	inf.	17	41
	juv.	50	38
	ad.	251	22
H. moloch	inf.	4	100
	juv.	15	73
	ad.	44	32
H. agilis	juv.	2	100
	ad.	23	35
H. pileatus	inf.	1	100
	juv.	3	100
	ad.	17	59
H. gabrielli	inf.	1	100
	juv.	2	50
	ad.	17	6
H. klossi	inf.	1	100
	juv.	1	100
	ad.	12	92
H. concolor	ad.	7	57
H. hoolock	ad.	3	67
H. leucogenys	juv.	1	0
	ad.	1	0
S. syndactylus	inf.	3	67
	juv.	3	100
	ad.	30	63

Fig. 28 Developmental variations and abnormalities in skulls of gibbons. A to D = single and multiple bregmatic fontanelle bones (note large fontanelle in infant A which has already a few incisors); E = left: fontanelle bone at lambda, right: fontanelle bone at asterion (note open temporo-mastoid suture); F = asteric fontanelle bones (double on left); G = pteric and asteric fontanelle bones; H = double pteric and asteric fontanelle bones, or divided alisphenoid (note contact between temporal and zygomatic bones); I = divided parietal bone, double asteric fontanelle bones and retention of sutura mendosa; K = os Incae unilaterale and lambdoid and bregmatic fontanelle bones; L = retention of metopic suture and bregmatic fontanelle bone; M = premature closure of right coronal suture, producing plagiocephalus; N = divided zygomatic bone, bilateral, in same skull as shown in L; O = vomer participating in formation of hard palate; P = divided zygomatic bone with abnormal shape of zygomatic arch.

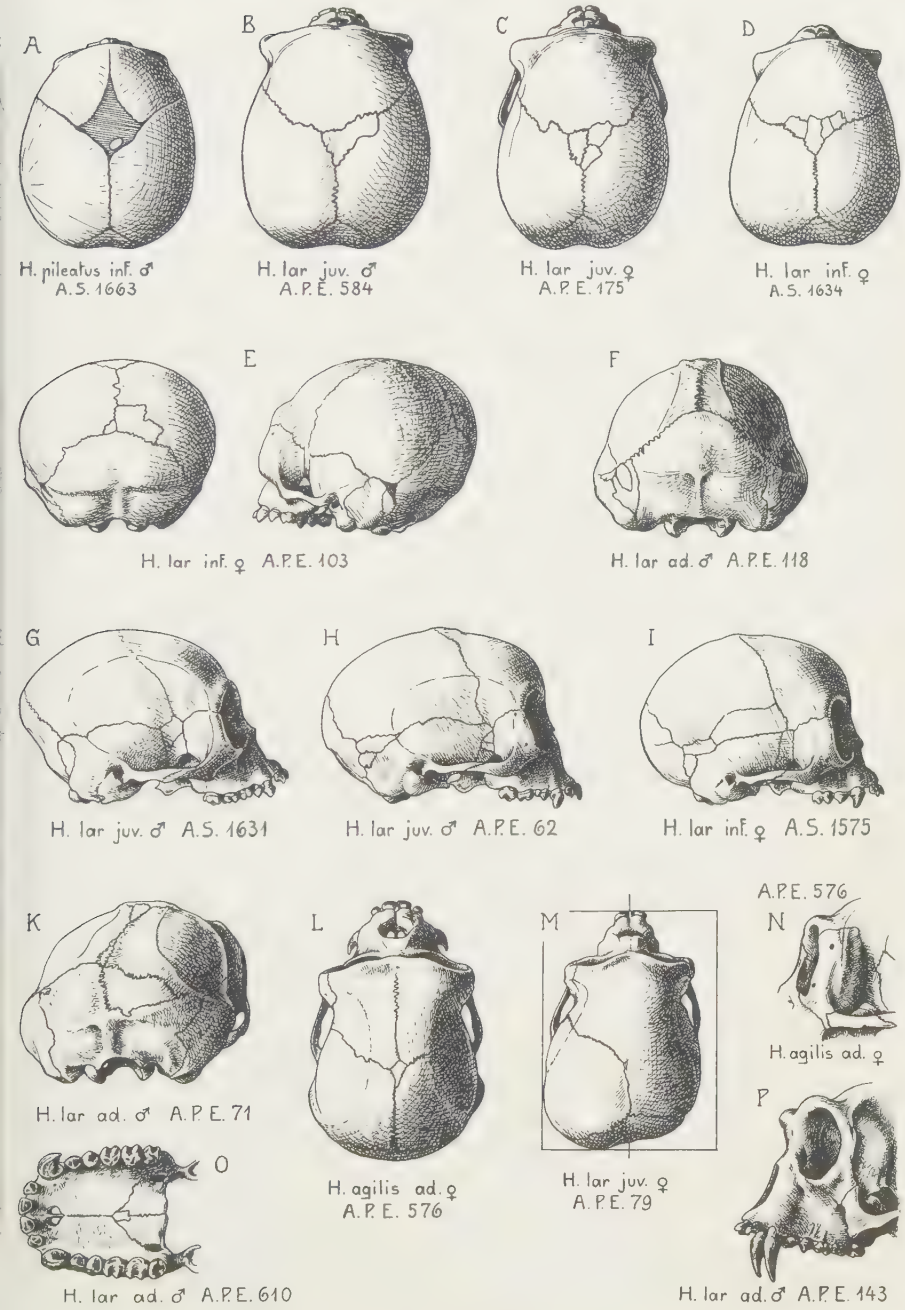
A
H. pileatus inf. ♂
A.S. 1663
B
H. lar juv. ♂
A.P.E. 584
C
H. lar juv. ♀
A.P.E. 175
D
H. lar inf. ♀
A.S. 1634
E
H. lar inf. ♀ A.P.E. 103
F
H. lar ad. ♂ A.P.E. 118
G
H. lar juv. ♂ A.S. 1631
H
H. lar juv. ♂ A.P.E. 62
I
H. lar inf. ♀ A.S. 1575
K
H. lar ad. ♂ A.P.E. 71
L
H. agilis ad. ♀
A.P.E. 576
M
H. lar juv. ♀
A.P.E. 79
A.P.E. 576
N
H. agilis ad. ♀
O
H. lar ad. ♂ A.P.E. 610
P
H. lar ad. ♂ A.P.E. 143

Figure 28

frequently in infants than in juveniles and more frequently in the latter than in adults. This fully supports the conclusion that the cranio-pharyngeal canal can become obliterated at any stage of development including the postnatal periods. There exist very marked specific and generic differences regarding the average age of disappearance of this canal. In man it closes normally during embryonic life and its rare persistence to adulthood is to be regarded as a developmental inhibition. On the other hand, in H. klossi, e. g., the canal does not normally become closed at all, as it was found in 11 of 12 adults, including several old specimens.

In the fontanelles of gibbons there can develop single or multiple bones of widely varying size and configuration, as has been shown by a number of authors, notably by Ranke (1899) and by Hopwood ('33). The present, extensive material of gibbon skulls is particularly suitable for studying the frequency of such deviations from normal cranial development. For these statistical determinations only such skulls can be used in which all main sutures are still visible, since the borders of fontanellar bones become obliterated at about the same time as the normal, adjoining sutures. The Chiengmai series contains 91 specimens with visible sutures. Among these there are no less than 42 skulls (= 46%) with one or more fontanelle bones. The latter are distributed as follows: Bregmatic bones in 14 skulls (9 times single, 2 times double, 2 times triple, and 1 time quadruple) (fig. 28, B, C, D); lambdoid bones in 5 skulls (1 time double) (E); asteric bones in 30 skulls (8 times unilateral only, 12 times double) (E to I); pteric bones in 7 skulls (5 times unilateral only). In 28 of these cases there is only one type of fontanellar bones, in the remaining 14 cases there are two types in each skull. Among the other gibbon skulls, examined by the author, there are 75 with visible sutures. This series contains 12 cases of bregmatic bones (once triple and once composed of even 6 pieces), 2 cases of lambdoid bones, 2 cases of asteric bones (both unilateral), and no cases of pteric bones. Altogether there are 15 skulls (= 20%) with 1 or more fontanellar bones in each. It is specially mentioned that no such abnormal bones were encountered in any specimens of H. moloch, in striking contrast to H. lar from Chiengmai, among which nearly one out of every two possesses these bones, and that among 22 H. lar of the Malay Peninsula only 18% have fontanelle bones, instead of 46%, as in the H. lar from Chiengmai. That the tendency to close fontanelles from supernumerary ossification centers is of a hereditary nature and can become almost a species character, appears most likely also in other groups of mammals. Thus, bregmatic fontanelle bones exist in a majority of the cases in the European hedgehog, the Canadian beaver and the North

American porcupines (Schultz, '23) and occur in 17.5% of Lynx rufus, whereas never in Lynx canadensis (Pratt, '42).

Of other cranial abnormalities in gibbons the following are specially rare and, hence, worth recording: 1. Abnormal suture in right parietal bone in an infantile H. lar (fig. 28, I). Completely or incompletely divided parietal bones are not infrequent in the orang-utan (Schultz, '41 a), but very rare in other primates and have never before been found in gibbons, though many have been examined by, e. g., Hrdlička ('03) and LeDouble ('03). 2. Complete division of the zygomatic bones in 3 gibbons (fig. 28, N, P). In all 3 of these cases the abnormal suture exists in the right and left zygomatic bones and in 2 of these cases both zygomatic arches are much enlarged, reaching far down in a very abnormal fashion, as shown in the sketch P. These 3 cases represent 2% of the 166 gibbon skulls with visible sutures. Among 166 orang-utan skulls the author ('41 a) found such divided zygomatic bones in nearly 7% of the cases. Hrdlička ('02) has described the same occurrence in an additional orang-utan. In man the incidence of completely divided zygomatic bones differs greatly in various races, being most common in the Japanese (3.2%, according to Martin, '28) and very rare in, e. g., aboriginal Americans (0.04%, according to Hrdlička, '02). 3. In one adult gibbon skull the right zygomatic arch is incompletely developed, having a vestigial central portion "floating" between the abnormally broad anterior and short posterior ends of the arch (fig. 25, I). LeDouble ('03) mentions a gibbon in the museum of Paris whose left zygomatic arch is incompletely developed and states that the same malformation exists in a lower catarrhine monkey, examined by him. It is noteworthy that the above gibbon (A. P. E. 9, ad. ♀) possesses still other abnormalities, namely a supernumerary incisor in the lower jaw and congenitally fused second and third vertebrae. 4. A unilateral Inca bone in a H. lar (fig. 28, K). This is not a mere fontanellar bone, but represents an abnormal division of the occipital squama, corresponding to the so-called Inca bones, occurring in man with high frequency in Peruvian skulls. As far as the writer can ascertain, the gibbon skull described here is unique, inasmuch as no Inca bones have before been reported for any primate, besides man. As happens in many cases, this specimen has more than one anomaly. Besides the Inca bone, it possesses a supernumerary premolar tooth. 5. The metopic, or interfrontal, suture, which normally disappears in gibbons before the close of the infantile period, has persisted to adult life in one H. agilis (fig. 28, L). Only the short, glabellar portion of this suture is closed and the remaining seven-eights of the suture are completely open. This is the first case of metopism in an adult gibbon that has ever been

recorded, even though well over 500 gibbon skulls have been examined for this condition by various authors, including the writer (see also Ashley-Montagu, '37). Again it is found that this abnormality is associated with other ones, inasmuch as the same specimen possesses divided zygomatic bones on the right and left sides and a midsagittal perforation of the manubrium sterni. 6. In 3 gibbons the coronal suture of one side is prematurely closed, producing a very marked asymmetry of the skull, a condition well known in man and called plagiocephalus (fig. 28, M). Exactly the same abnormality has been described by the author ('26) in 4 adult, wild howler monkeys. 7. In 2 adult gibbons the vomer participates in the formation of the hard palate by appearing at the intersection of the sagittal and transverse palatine sutures (fig. 28, O). This same rare, abnormal condition has been found in an orang-utan (Schultz, '41 a) and in a few skulls of man and other mammals [26] (Killermann, 1894).

This long list of abnormalities in gibbons shows the amazingly high frequency of cases in which one bodily structure or another can deviate profoundly from the normal course of its development and this in wild animals. Abnormalities in the skeleton and dentition alone occur in the Chiengmai series of 233 gibbons in 47% of the animals. In the males this percentage is higher than in the females, namely 56, as contrasted with 37. These figures include only the more significant defects, that have been recorded here, and leave out of consideration such conditions as crowding and twisting of teeth, perforation of the sternum, abnormal curvature of long bones, and reductions in digits affecting only the size. It has been pointed out repeatedly that several and quite unrelated developmental abnormalities can occur in one and the same individual, thus indicating a general lack of normality in the processes of embryonic differentiation. To mention briefly a few more specific instances of multiple defects in individual gibbons, the following 3 cases may here be added: 1. Adult skeleton with retention of deciduous tooth, syndactyly, and incomplete formation of atlas and of one digit. 2. Adult skeleton with incomplete twinning of both lower canine teeth, congenital lack of both lower third molars, two fully formed ribs from seventh vertebra, and large bregmatic and asteric fontanelle bones. 3. Adult skeleton with polydactyly and congenital lack of all third molars and of one lower incisor.

[26] In the skulls of 3 adult domestic cats of the author's collection the vomer appears on the palate in exactly the same fashion as in the gibbon shown in figure 28 (O). It may be mentioned that these are the only cases of this nature among well over 100 skulls of Felidae examined by the writer.

SKELETAL PATHOLOGY

In the skeletons of wild gibbons one encounters frequently unmistakable evidence of fractures which must have occurred long before death of the individual since they have become repaired with widely varying degrees of bony changes. Examples of healed fractures in adult wild gibbons are shown in figure 29 and have also been published in another paper by the author ('39). At times such fractures have failed to become repaired, though being evidently of long standing (e. g., fig. 29, L, O). In other instances, however, the process of healing has been remarkably successful, considering that it was left, of course, to nature alone (e. g., A, I, P). There are several cases in which fractured long bones of the limbs have mended without having become significantly shorter than the corresponding, uninjured bone of the opposite side (Schultz, '39, p. 579). In 1 gibbon the body of the mandible had been fractured in nearly the same manner and had healed fully as well as in the case of a fractured mandible of prehistoric man, described by Breitinger ('39), which was used in support of the unconvincing conclusion that the art of "bone setting" must be very ancient.

The data in table 43 show first of all that the incidence of healed fractures rises sharply with advance in age. In the Chiengmai series fractures are lacking among infants,[27] but they occur in over half of the old males. Among all adults, including senile specimens, fractures exist in 28% of the females and in 37% of the males. The corresponding figures for adult orang-utan (total examined = 60 complete skeletons) are very similar, namely 30 for females and 36 for males (Schultz, '41 a). In adult wild African apes healed fractures are not nearly as frequent, having been found by the writer in only 2 (= 13%) out of 15 complete skeletons of chimpanzees and in 2 (= 18%) out of 11 complete skeletons of gorillas.[28] Among the 233 gibbon skeletons from Chiengmai there is

[27] Among all other infantile gibbons, examined by the writer, there is only 1 specimen with healed fractures, namely a H. lar from an unknown locality in Siam which has both tibiae and the left fibula broken in the middle of the shafts and healed in strongly bent manner with marked callous formation.

[28] Among the humeri, radii, femora, tibiae, and clavicles alone healed fractures have been found in 9 (= 11%) out of 84 sets from adult wild chimpanzees and in 9 (= 7%) out of 127 sets from adult wild gorillas (Schultz, '37 a). According to Randall ('43–'44) healed fractures on the skull alone exist among wild adult gorillas in 2% of 123 females and in 6% of 213 males.

Randall states that: "A study of the frequencies of fractures and various indications of other pathological conditions in the skeleton is apt to produce a misleading conclusion. This is due to the fact that the very possession of such conditions may render animals more likely to be met and killed by the hunter." Based upon his extensive field experience in hunting primates, the writer can not at all agree with Randall's view. Injured apes are more alert to danger, less inquisitive and, being quiet, less apt to be detected than the healthy, restless, noisy members of their groups. Furthermore, the predatory carnivores are more numerous and persistent than human hunters and would promptly eliminate injured apes, if this were easy. The very fact that so many specimens have survived fractures sufficiently long for complete healing to take place and to keep on living to senility, proves that these percentages of healed fractures are not unnaturally high, but may rather be too low, since some very severe fractures undoubtedly kill the animal in a short time.

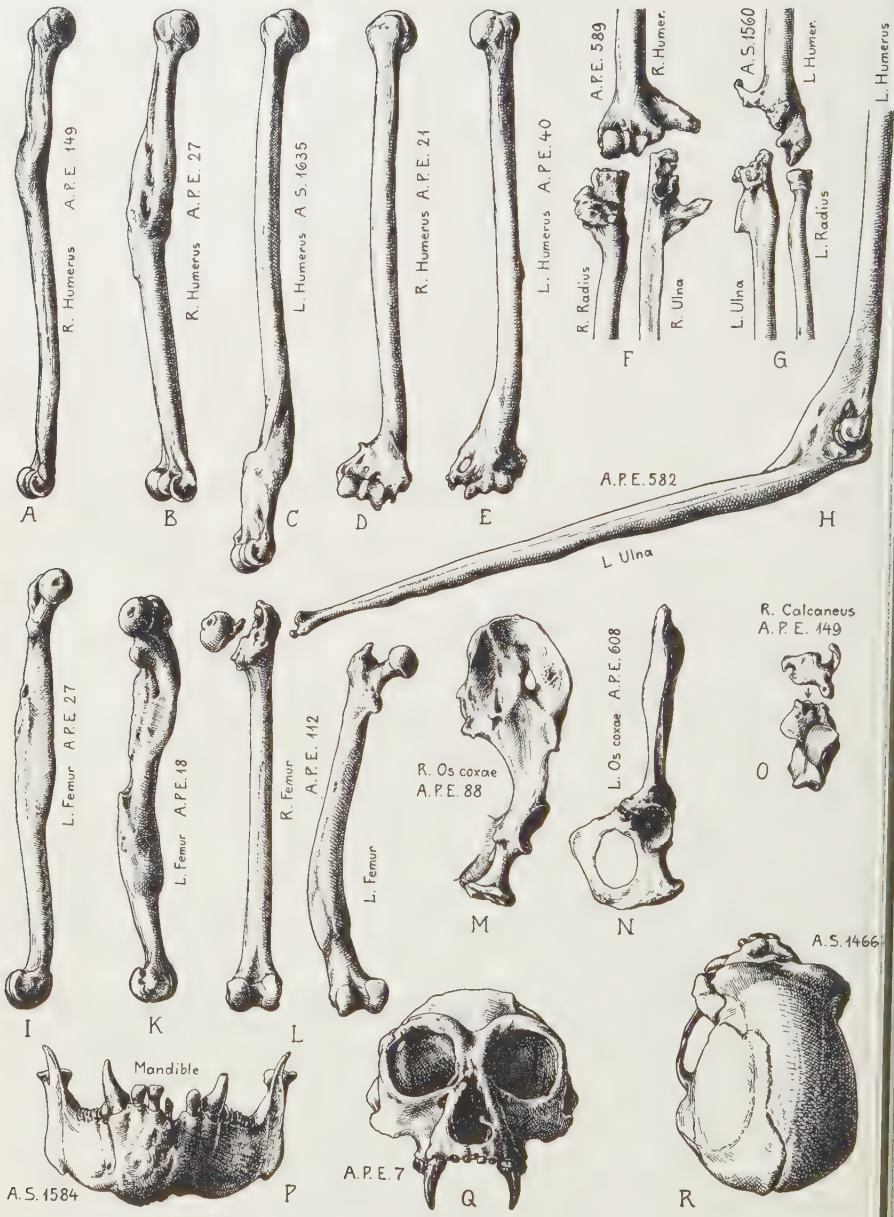
R. Humerus A.P.E. 149
A
R. Humerus A.P.E. 27
B
L. Humerus A.S. 1635
C
R. Humerus A.P.E. 21
D
L. Humerus A.P.E. 40
E
A.P.E. 589
R. Humer.
R. Radius
R. Ulna
F
A.S. 1560
L. Humer.
L. Ulna
L. Radius
G
L. Humerus
A.P.E. 582
H
L. Ulna
L. Femur A.P.E. 27
I
L. Femur A.P.E. 18
K
R. Femur A.P.E. 112
L
L. Femur
R. Os coxae A.P.E. 88
M
L. Os coxae A.P.E. 608
N
R. Calcaneus A.P.E. 149
O
Mandible
A.S. 1584
P
A.P.E. 7
Q
A.S. 1466
R

Figure 29

TABLE 43

Percentage frequencies of healed fractures in different age and sex groups of the 233 H. lar of the Chiengmai series and distribution of these fractures among skeletal parts.

AGE AND SEX	TOTAL OF SPECIMENS	PERCENTAGE OF SKELETONS WITH 1 TO 7 FRACTURES EACH
Infants ♂ & ♀	11	0
Juveniles ♂ & ♀	38	13
Adults ♀	68	22
Adults ♂	78	33
Seniles ♀	19	47
Seniles ♂	19	53

These fractures are distributed among the different skeletal parts of the above 65 specimens as follows:

Humerus	16 times	Tibia	4 times
Femur	15 times	Metacarpus	3 times
Phalanges	13 times	Mandible	3 times
Ribs	12 times	Carpus	2 times
Ulna	10 times	Orbit	2 times
Pelvis	7 times	Sternum	2 times
Clavicle	7 times	Metatarsus	1 time
Fibula	6 times	Tarsus	1 time
Radius	5 times	Zygomatic arch	1 time
Scapula	5 times		

Total = 115 bones with at least one fracture each.

a total of 115 healed fractures; the latter figure equals 49.4% of the former figure. In man this percentage is very much lower, as is indicated by the following example: Smith and Jones ('10) have listed the healed fractures encountered in the skeletons of the ancient inhabitants of Nubia; among approximately 3000 individuals from the two largest cemeteries there were altogether 33 healed fractures which form only 1.1% of the number of skeletons, instead of 49, as in the gibbons. Even though it is admitted that these widely different figures may not be strictly comparable on account of differences in the age composition of

Fig. 29 Examples of healed fractures in adult wild gibbons. A to E = fractured humeri of 5 different specimens (A and B have fractures in upper half of shaft, C to E at distal end); F and G = fractures and subsequent infection of elbow joint in two different specimens; H = fractured (?) elbow and ankylosis between humerus and ulna; I to L = fractures of femur in 3 different specimens (I is same animal as B), K has two fractures of shaft, L has unrepaired fractured neck on right with formation of false joint lateral to head of femur; M = fractured ilium; N = incompletely healed fracture of acetabulum; O = unrepaired, old fracture of calcaneus with abnormal process on distal portion (same animal as A); P = fracture at mandibular symphysis; Q = fractures at right orbital rim, nasal bones and apertura piriformis; R = incompletely healed fracture of brain case from foramen magnum to left orbital rim. All these specimens are H. lar and all, except R, belong to the Chiengmai series.

the two series or in other factors, it is certain that no population sample of man contains nearly as many healed fractures as the sample of gibbons or that of orang-utans.[29] The extremely arboreal mode of life of these apes is undoubtedly the chief cause of this enormously high incidence of fractures. It is particularly remarkable that these apes can survive even very severe fractures, such as that of the skull shown in figure 29, R,[30] and that others can live and thrive after having suffered as many as seven fractures.[31]

The different skeletal parts of gibbons become fractured with widely differing frequency, as shown by the data in table 43. Humerus and femur are most likely to become fractured, whereas the bones of the forearm and of the leg are much less often injured. The same can be said in the case of orang-utan, but in man just the opposite relation prevails in this regard, at least as a general rule (e. g., Smith and Jones, '10, p. 295). Finally, it is mentioned that of the 115 gibbon bones with healed fractures 43 belong to females and 72 to males. This again indicates that males are more apt to become injured than females and this, probably, due to fights between the former.

The skeletons of wild gibbons contain many and marked pathological changes besides those due to fractures, as shown by the examples in figure 30. No attempt will be made here to discuss all these pathological conditions in detail, since the chief interest lies in the frequency of their occurrence. The following general types of bony changes could be observed in the Chiengmai series alone: 1. Hypertrophy of bony tissue on the shafts of long bones, manifested by irregular and striking thickening of the diaphysis of a radius (fig. 30, A), an ulna (2 specimens), a tibia, and a fibula (total = 5 cases). 2. Atrophy of tibia and fibula of one leg in 2 specimens, the affected bones being of practically the same length as the corresponding bones of the other, normal leg, but

[29] Among 92 orang-utans, including all postnatal age stages, there is a total of 49 healed fractures (Schultz, '41 a). The percentage relation between the latter and former figures equals 53.3 and is even higher than the corresponding value for gibbons.

[30] Duckworth ('12) describes the case of an adult wild orang-utan of which he states: "That an animal with the jaw fractured on both sides, and practically the whole face separated from the cranial base, should have lived long enough for processes of repair to commence is little short of marvelous."

[31] Among the gibbons from Chiengmai there is one with healed fractures of the lower jaw, r. fibula and r. ribs II, III, V, VII, and VIII and another with repaired fractures of the mandible, l. zygomatic arch, l. radius, and r. clavicle. In a third specimen one humerus and both hip bones had been fractured and this, most likely, in one and the same accident, since healing had progressed equally far in all three places. In still another specimen both hip bones had been fractured and the r. temporal muscle had evidently been injured, it was atrophic, contained much scar tissue and its attachment to the cranial vault was abnormal, as shown in figure 21, C.

of barely half normal thickness. 3. Diseased joints in which the articular surfaces are enlarged, irregularly formed, bearing exostoses, and being partly porous. This condition was found in the sterno-clavicular joint in 11 specimens (7 times unilaterally, 4 times bilaterally) (fig. 30, B), in the mandibular joint in 5 specimens (3 times unilaterally, 2 times bilaterally) (B), in the hip joint in 5 specimens (5 times unilaterally) (D, E, F), in the shoulder joint in 5 specimens (4 times unilaterally, once bilaterally), in the elbow joint in 4 specimens (4 times unilater-

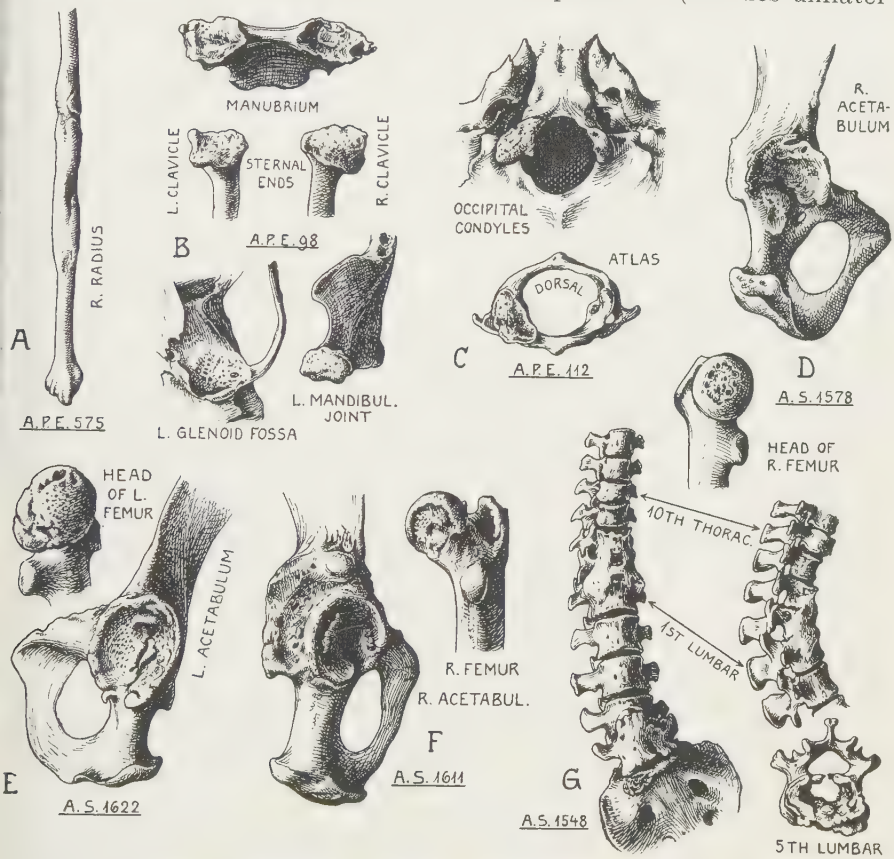

Fig. 30 Examples of pathological changes in skeletal parts of adult wild gibbons. A = diseased shaft of radius; B = diseased r. & l. sterno-clavicular joints and l. mandibular joint from one skeleton; C = diseased r. atlanto-occipital joint; D to F = diseased hip joints in 3 different specimens, showing acetabulum and head of femur in each; G = arthritic changes in vertebral column, ventral and lateral views, showing exostoses (which had firmly united the 12th and 13th thoracic and 1st lumbar vertebrae), and (enlarged) view of last lumbar vertebra showing erosion in vertebral body. All these specimens are H. lar of the Chiengmai series, except G which is a H. moloch.

ally), in the knee joint in 3 specimens (3 times unilaterally), in the joints of the wrist in 1 specimen (unilaterally), in the atlanto-occipital joint in 1 specimen (unilaterally) (C), and in one or several interphalangeal joints in a marked degree in 4 specimens and in a slight degree in many additional specimens (the latter are not included in the calculation of percentage frequencies). 4. Exostoses, and sometimes also partial erosion, of the bodies of vertebrae in a total of 13 specimens from Chiengmai. These particular pathological changes occur most frequently on lumbar vertebrae, but have also been observed on the last one or two thoracic, the first sacral, and the last few cervical vertebrae. A very marked example of this condition is shown in figure 30, G.

These vertebral changes, as well as many of the diseased conditions in the joints, listed under 3, are typical of chronic arthritis. Exactly the same sort of arthritic changes in wild primates have been described and illustrated by Fox ('39), who observed them in gorillas, orang-utans and baboons, but not in any of 22 gibbons. Moodie ('31) also has recorded extensive arthritic changes, closely corresponding to those found here in gibbons, in the vertebrae of a mummified baboon of ancient Egypt. Fox had concluded that chronic arthritis occurs only in "macrosomic animals" and is absent in the smaller mammals. This can no longer be maintained in view of the fact that typical arthritic changes of vertebrae exist in many gibbons (in a total of 15 specimens, seen by the author), have been recorded for a proboscis monkey (Schultz, '42 a) and have been encountered by the writer in several macaques. It is noteworthy that of the 13 gibbons from Chiengmai with arthritic exostoses on the vertebrae 10 are senile specimens. Manifestations of arthritis in the spinal column are frequently, but not always, associated with other pathological changes in the skeleton and dentition. To mention a few such cases: One old female gibbon has very marked exostoses on the fifth lumbar and the first sacral vertebrae, the right hip joint is extensively diseased, one interphalangeal joint shows arthritic changes and has become ankylosed, there are two alveolar abscesses, and carious cavities in two molar teeth. In another old female there are numerous exostoses on the ventral margins of the bodies of several cervical, lumbar and first sacral vertebrae, both sterno-clavicular joints are much diseased and there is one alveolar abscess. In an old male gibbon the last thoracic, 2 lumbar and the first sacral vertebrae bear unmistakable arthritic exostoses, both sterno-clavicular and both mandibular joints are extensively diseased, the left olecranon and the proximal ends of both humeri have developed irregular bony processes, and there are four large alveolar abscesses.

The pathological conditions of the skeleton (without fractures), discussed above, exist in 40 out of the 233 wild gibbons of the Chiengmai series. Nineteen of the former are males and 21 females. Among the different age groups they are distributed as follows: Marked pathological changes in the skeleton (without healed fractures) have not been found among 11 infants, but exist among 38 juveniles in 1 specimen (=3%), among 146 adults (without old specimens) in 18 specimens (=12%) and among 38 seniles in 21 specimens (=55%). It is very evident that the incidence of these disease processes rises very rapidly with advance in age. Among the 38 senile gibbons from Chiengmai there are only 6 specimens without any pathological conditions in the dentition or in the skeleton, if healed fractures are considered also.

SUMMARY

The gibbon is the only one of the man-like apes which still survives in vast numbers and hence it can be studied with statistically adequate material. As all anthropoid apes, the gibbon is in many respects extremely variable so that large series of specimens are essential for obtaining averages which really represent closely the typical conditions. For the present investigation a sample of a wild gibbon population has been available. Based chiefly upon this material it has been possible to analyze not only the morphological changes with advance in age and the ranges of individual variations in many metric and other features, but also the composition of a typical group according to age and sex, as well as the frequency of developmental defects and the prevalence of pathological conditions. Comparative data of this nature are much needed as a basis for the study of man.

It has been the principal purpose of this paper to record fully the many morphological findings in gibbons derived from detailed observations on mostly new material. Thus, this study forms a contribution to the science of primatology which aims to provide comprehensive and reliable knowledge of all non-human primates as the essential background for a complete understanding of the primate nature of mankind.

Some of the morphological characters of gibbons have here been compared with the corresponding conditions in a few of the many other primates. It must be emphasized that these limited comparisons are only of a preliminary nature and that broad generalizations will not become possible until many additional comparative data have been recorded. That this report deals almost exclusively with the metric features of the outer body and with the dentition and skeleton, is due to the

nature of the available material and the limitations incident to collecting and observing in remote jungles.

The gibbon material used in this study consists of the following series: 1. One hundred and seven Hylobates lar from one mountain in northern Siam (= Angka series). These specimens and 6 additional infants and fetuses had been measured in the flesh and supplied the data for the study of body proportions. 2. Two hundred and thirty-three skeletons of H. lar (including the skeletons from the Angka series) from the limited district of Chiengmai in northern Siam (= Chiengmai series). 3. Forty-four additional skeletons of various gibbon species, together with the Chiengmai series, constitute the General series I which forms the basis for the study of conditions, typical of the entire genus Hylobates. 4. A General series II is composed of the previous series and varying numbers of additional specimens (mostly skulls) and is used in the analysis of such problems as the sequence of eruption of the teeth and the order of suture closure.

One fourth of these gibbons are of pre-adult age, about 58% are adults, collected in the prime of life, and the remaining 17% are senile. On a general average, there are 91 female to every 100 male gibbons. The percentage of pregnant females among all adult wild females equals 13 in gibbons and anywhere between 9 and 50 in series of seven other types of primates, collected by the author. It appears most probable that gibbons do not become pregnant until some time after they have acquired their full dentition. It can also be concluded that gibbons have no breeding season.

Adulthood in gibbons is reached toward the end of the ninth year, according to the scant, available evidence. At birth the gibbon weighs approximately 400 gm. The average body weight of adult Hylobates lar equals 5.3 kg. in females and 5.7 kg. in males; the range of individual variations is enormous, extending among adults from 3.9 to 7.3 kg. The birth weight amounts to 6.7% of the weight of adult females, which is the highest ratio found so far among primates.

The most significant age changes in the body proportions of gibbons are briefly enumerated in the following: The trunk becomes more slender during the interval between the fetal and the early juvenile periods of growth, but becomes stouter again late in postnatal life, especially in the males. The relative shoulder breadth decreases in infantile life, to increase thereafter. The relative hip breadth decreases in general during growth and does not differ in the two sexes, even among adults. The proportionate size of the pelvic inlet, however, is significantly greater in adult females than in adult males. The chest becomes

relatively broader with advance in age. The height of the chest, as represented by the length of the sternum, equals at all ages about one fifth of the trunk height and is significantly shorter in females than in males. The proportionate lengths of the various spinal regions change with age, those of the cervical, thoracic and coccygeal portions decrease and that of the lumbar portion increases.

The relative length of the lower limb becomes greater from fetal to juvenile life, but somewhat smaller again thereafter. The upper limb grows in length more rapidly than the trunk and also more rapidly than the lower limb. The relation in length between tibia and femur changes comparatively little with age, but that between radius and humerus shifts very markedly since the forearm grows more intensively than the upper arm. The relative lengths of the foot and of the hand increase during late fetal life, to decrease again in the postnatal periods of growth. The relative widths of foot and of hand decrease with advancing age, a change which is particularly marked in the hand. The relative length of the thumb diminishes somewhat ontogenetically. The main segments of the foot grow at widely differing rates, thus the tarsus becomes proportionately shorter with age and the phalanges form gradually a much larger percentage of the total foot length. The middle digit of the foot and of the hand is always the longest. The second finger is longer than the fourth in the great majority of the specimens of the Angka series, but the second toe is shorter than the fourth in most cases.

The relative size of the average diameter of the head decreases very strikingly with advancing age, as the brain grows very rapidly early in life and increases very slowly later on. The cranial capacity at birth has already attained over 60% of its final size, but the body in general has reached less than 10%. The face grows less rapidly than the trunk, though more intensively than the brain part of the head. The cephalic index undergoes comparatively little change with age, but the cranial length-width proportion becomes considerably altered ontogenetically, since the length of the brain case increases more than its width and, incidentally, more than its height. The face gains more in height than in breadth with advancing age. The orbits grow rapidly during early life, reaching nearly half their final size in the infantile period. They migrate postnatally from a position entirely underneath the brain case to one largely in front of it. The relative width between the eyes decreases markedly during early growth, but increases again in juvenile life. The greatest proportionate size of the outer ears is attained in the infantile period whereafter the relative ear size is somewhat reduced.

The body proportions of gibbons are compared with those of spider monkeys, macaques, proboscis monkeys, orang-utans, chimpanzees, and men and this at fetal and at adult stages. With few and detailed exceptions there exists a much greater resemblance between these primates among the fetuses than among the adults. The general growth trends of most the proportions are strikingly similar in all the types compared, though the degres of ontogentic change can often differ considerably, especially late in growth. The outstanding specialization among the proportions of the gibbon consists in the enormous lengthening of the upper extremities, due most of all to the unique relative length of the forearm.

From detailed comparisons regarding the precise degrees of variability in proportions of the outer body and of skeletal parts it is concluded that, in general, the wild gibbons of the Angka and Chiengmai series are as variable as are individuals in the average human series. The body proportions of the gibbons have a greater variability than those of wild spider monkeys. In regard to some skeletal proportions the gibbons of the geographically very limited series from Chiengmai show as high a variability as do other primates in series composed of specimens from widely distributed localities.

The variability of gibbons has also been studied by means of the numbers of vertebrae in the different spinal regions. The cervical vertebrae vary numerically in rare instances only. Among 314 gibbons 3 possess only 6 cervical vertebrae and one has 8. The thoracic region is composed of 12, 13 or 14 segments, but increases in the modal number of 13 are several times more frequent than are decreases; the mode itself exists in 83% of the cases. Six, 7 or 8 pairs of ribs reach the sternum directly, a fairly close correlation existing between the total number of ribs and the number of sternal ribs. The number of lumbar vertebrae varies between 4 and 6, the latter extreme being much more common than the former. Five lumbar vertebrae are found in 76% of the cases. Gibbons possess anywhere from only 3 to as many as 6 sacral vertebrae, the modal number of 5 occurring in only 51% of the specimens. The exact position of the sacrum in relation to the hip bones varies to a remarkable extent and appears to be partly dependent upon the number of presacral segments. The coccygeal portion of the spine is the most variable one, this region having anywhere between 0 and 6 vertebrae, the modal number of 3 existing in only 39% of the cases. The total number of vertebrae varies among gibbons between 30 and 36, 32 being found most frequently. According to all available evidence there prevails a hereditary trend for the occurrence of most of these

vertebral variations. The most frequent combination of regional variations in the vertebral columns of gibbons is 7 cervical, 13 thoracic, 5 lumbar, 5 sacral, and 3 coccygeal segments. This formula, however, is found in only 13% of the specimens and each of all other combinations is even less frequent. The statistical norm for the numbers of different vertebrae in man occurs in a far higher percentage of cases, i. e., the human spine is very much more constant than is that of the gibbon.

Bilateral variations, or asymmetries, have been studied chiefly on the long bones of the limbs and the clavicles. In the upper extremities of gibbons asymmetries favor the left side much more frequently than the right, but in the lower extremities, as well as in the clavicles, asymmetries favor both sides with similar frequency. The average degree of asymmetry is practically alike in the upper and the lower limbs and is highest in the clavicles. These new data supplement those recorded in a former study of asymmetries in chiefly the great apes and man and support the conclusions reached previously.

In the gibbon, in lower catarrhines and in man the deciduous teeth erupt in the following order: middle incisors, lateral incisors, first molars, canines, and second molars. In all the great apes this sequence differs, inasmuch as the second molars appear before the canines. The permanent dentition of the gibbon has the following order of eruption: Lower first molars, upper first molars, lower and upper middle incisors, lower lateral incisors, upper lateral incisors, lower second molars, upper second molars, lower and upper first and second premolars in rapid and irregular succession, lower canines, upper canines and lower third molars, upper third molars. This sequence agrees very closely with that characteristic of great apes, but differs significantly from that found in recent man.

The deciduous incisors of gibbons occlude with overbite in about two thirds the cases and meet edge to edge in one third of all specimens. Among adult gibbons overbite is found in 41% of the cases, edge to edge bite in 54% and underbite in the remaining 5%. Gibbons are exceptional among catarrhines by having very large permanent canines in both sexes. On an average, however, the canines of males are significantly larger than those of females.

The normal postnatal development of the gibbon skeleton is described in detail and compared, as far as possible at present, with the corresponding conditions in some other primates. The latter comparisons, being of necessity incomplete and tentative, are not summarized here. The most significant age changes in the skeleton of gibbons are listed below:

The dorsal arches fuse with the vertebral bodies during infantile life. The costal elements of the first 2 (or 3) sacral vertebrae are separate until the end of the juvenile I period. Bony fusion between the ventral arch and the lateral portions of the atlas occurs early in the juvenile II period. Ossification in the epiphyseal plates of the vertebrae starts during the juvenile II period, but these epiphyses do not join the bodies until some time after the completion of the permanent dentition. Transverse foramina of the seventh cervical vertebra develop in only a minority of the cases.

The sternum of gibbons ossifies in a most variable manner and is peculiar chiefly on account of the fact that in nearly all cases the part representing the two uppermost intercostal segments forms one single bone, derived most frequently from 1 center only. The corpus sterni develops from anywhere between 3 and 8 ossification centers which fuse in highly irregular fashion and at widely differing ages. The xyphoid process becomes normally ossified, remaining entirely cartilaginous in very rare cases. It is quite commonly forked.

The bony rami of ischium and pubis become united at the age of appearance of the last milk teeth. The ilium and ischium begin their bony fusion toward the end of the juvenile II period. Ilium and pubis fuse at the time of eruption of the last permanent teeth and this is followed by the coalescence of ischium and pubis early in adult life. A separate acetabular bone exists in about half of all gibbons from the juvenile II period. The bony rims of the ischial tuberosities do not fuse with the ischia until early in adult life and the epiphyses at the iliac crests become joined with the iliac blades even somewhat later. Synostosis of the pubic symphysis occurs with increasing frequency during the later stages of adulthood and is very common in old males.

The sternal epiphyses of the clavicles close usually not until the teeth have become moderately worn. The ossification center for the coracoid process appears about the time of birth. This process loses its separate existence toward the close of the juvenile period. The acromion and vertebral border of the scapula remain cartilaginous until late in juvenile life and the lower angle of the shoulder blade often is still incompletely ossified in adults with considerable wear of the teeth.

All primary ossification centers of the limbs have appeared at birth, except those for some of the tarsal and carpal elements and that for the patella. Newborn gibbons possess already a varying number of the secondary, or epiphyseal, centers, being slightly more advanced in this respect than newborn man. The order of appearance of the postnatal secondary ossification centers could be established only tenta-

tively. The period of bony fusion between the epiphyses and shafts of limb bones begins in the gibbon just after the age of eruption of the second permanent molars and extends far into adulthood. On a general average, these epiphyses close in the following order: Humerus, distal; medial epicondyle; ulna, proximal; small trochanter; radius, proximal; great trochanter; head of femur; phalanges; tibia, distal; fibula, distal; metacarpals; metatarsals; fibula, proximal; tibia, proximal; femur, distal; radius, distal; ulna, distal; humerus, proximal. In a more condensed manner it can be stated that epiphyseal union occurs generally first at the elbow, then at the hip, ankle, knee, wrist, and last at the shoulder. A supratrochlear foramen of the humerus does not develop until early in juvenile life and persists to adulthood in about 1 out of every 4 specimens. In old age the os centrale of the wrist tends to become fused with the naviculare.

In the newborn gibbon the lambdoid and pteric fontanelles are completely closed, but the bregmatic and asteric fontanelles are still wide open. The closure of the pteric fontanelles is accomplished by the surrounding cranial elements in a varying manner. In two thirds the cases the alisphenoid meets the parietal, in one fourth the cases the temporal meets the frontal (and occasionally also the zygomatic), and in the remaining few specimens these conditions differ on the right and left sides. The mandibular symphysis becomes closed immediately after birth, at which time the temporo-mastoid sutures usually disappear. The metopic suture obliterates toward the end of the period of eruption of the deciduous teeth. This is followed by the gradual fusion between the different occipital elements which ends with the coalescence of the basioccipital and the lateral occipitals in the juvenile I period. The age of onset and the progress of obliteration of the facial part of the premaxillary sutures are very variable. These sutures disappear generally during the last phase of juvenile life and the beginning of adulthood. The internasal suture remains open to the age of completion of the second dentition. The nasal bones of all gibbons are extremely variable and can at times be entirely lacking. The sutures of the palate do not become closed until the dentition is moderately worn. The sutures of the brain case undergo obliteration some time after adulthood has been attained, the closure starting in general with the sagittal and basilary sutures, proceeding with the lambdoid suture, and ending with the coronal suture. The last of the larger sutures to close are the occipito-mastoid sutures. In specimens with comparatively small cranial capacities the right and left temporal lines can meet on top and in extreme cases a midsagittal crest develops in males as well as in females. Dur-

ing old age the skull becomes much lighter due to senile artophy of the bones, a process which can affect also the ilium and the scapula.

Having dealt with the normal development of the dentition and the skeleton in the gibbon, the occurrences of abnormal development will be briefly enumerated. Anomalies of the deciduous dentition are very rare in gibbons. In the second dentition, on the other hand, congenital defects are surprisingly common. One to 4 of the third molars have failed to develop in 4% of the Chiengmai gibbons and in over 2% of these specimens 1 or 2 of the incisors are congenitally lacking. Incomplete twinning of a tooth exists in 4 gibbons and complete twinning, producing supernumerary teeth, in 7 cases. One gibbon possesses fourth molars on both sides of both jaws and in addition a small, upper, left, fifth molar. Reductions in the normal number of teeth are nearly 4 times as frequent as are increases. In over 2% of all gibbons examined some deciduous teeth have been retained to adult life. Very pronounced crowding of teeth has been recorded for 7% of the specimens. Twisted and impacted teeth have also been noted in a considerable number of cases. Congenital malformations of one sort or another exist in the dentitions of the gibbons from Chiengmai in 26% of the cases.

The skeleton of gibbons frequently departs from its normal development. The outstanding abnormalities of the vertebrae and ribs are the following: In 1 specimen the atlas is incompletely separated from the occiput. Various forms of incomplete development of the atlas exist in nearly 9% of the Chiengmai gibbons and congenital fusion between 2 or more cervical vertebrae occurs in over 2% of these specimens. Incomplete and even complete ribs, belonging to the seventh vertebra, exist in 5 gibbons and entire or partial suppression of the ribs from the eighth vertebra have been found in 4 gibbons, indicating an unusual instability of the border between the cervical and thoracic regions. In 2 specimens some of the thoracic vertebrae have developed in abnormal, asymmetrical fashion and in several additional specimens some of the ribs are incompletely formed. Aberrant development of the sternum is represented mainly by 2 cases of suprasternal ossicles and by 15 cases of congenital perforations in the corpus sterni and (once) in the manubrium.

Of the many developmental defects in the extremities the following are specially noteworthy: One gibbon of the Angka series has the left upper limb undeveloped, except for the distal, stunted end of the upper arm. In another gibbon the right radius is incompletely formed. In several additional specimens there exists abnormal, partial fusion

between radius and ulna or between tibia and fibula. The digits of the feet and hands of gibbons are malformed with surprising frequency and in a great variety of manners. Among the 113 specimens of the Angka series alone there are 10 cases with supernumerary digits, 10 cases with various degrees of congenital reductions of digits, and 4 cases with abnormal fusion between bones of the digits. Altogether this series contains 18 specimens (= 16%) with one or several marked digital defects in each. Many additional cases of congenital malformations in the feet and hands of other primates are recorded and it appears that anomalous digits are exceptionally common in Hylobates lar from northern Siam.

In gibbon skulls the following deviations from normal development have been observed: The embryonic cranio-pharyngeal canal has remained open in 30% of adults. One or more of the different fontanelles have been closed with the aid of single or multiple fontanellar bones in nearly half of all specimens from Chiengmai. In all probability there exists a hereditary trend for the development of such supernumerary ossification centers. A divided parietal bone has been found in 1 gibbon, divided zygomatic bones in three, and a divided occipital squama in still another specimen. The metopic suture has remained open in one adult gibbon and the coronal suture of one side has become closed abnormally early in 3 specimens which consequently have very asymmetrical skulls.

In many instances an individual gibbon possesses several unrelated anomalies, thus showing a general instability in its development. One or more abnormalities in the skeleton and dentition alone could be recorded for nearly half of all the wild gibbons from Chiengmai. All these developmental disturbances occur also in modern man in practically identical form, but with a much smaller total frequency.

Pathological conditions in the teeth and bones of wild gibbons become steadily more numerous with advance in age and exposure to the hazards of living. The deciduous dentition was found to be entirely free of pathological changes. Carious cavities are absent in juveniles, but exist in about 1% of adults, with at most moderate wear of the teeth, and in 9% of the old animals. Alveolar abscesses appear in 1.7% of juveniles, affect 7.5% of adults and have developed in 38.5% of seniles. In the Chiengmai series alone these figures are higher in all age groups. In a total of 104 senile gibbons there are 55 with each at least one diseased tooth or alveolus. In many of the latter the dental apparatus had become nearly useless on account of extreme attrition, numerous abscesses and loss of teeth.

Among the pathological conditions in the skeleton of wild gibbons the symptoms of repair of former fractures are most common. The incidence of healed fractures rises sharply with age. In the Chiengmai series fractures are absent among infants, but occur in over half of all old males. This series contains a total of 115 healed fractures. The latter are found most commonly in the humerus and femur, but can occur also in nearly all other skeletal parts, including the skull. Healed fractures are considerably more frequent in males than in females. Of other pathological changes in the skeleton the following are specially noteworthy: Hypertrophy and atrophy of long limb bones in 7 specimens. Diseased joints occurring in one or both sterno-clavicular articulations in 11 cases, in the mandibular joints in 5 cases, in the hip in 5 cases, in the shoulder in 5 cases, in the elbow in 4 cases, in one or several interphalangeal joints in at least 4 cases, in the knee in 3 cases, in the wrist in 1 case, and in the atlanto-occipital joint in 1 case. In 1 gibbon humerus and ulna are ankylosed. Arthritic changes in the spinal column, leading in advanced cases to irregular bony union between 2 or more vertebrae, exist in 13 specimens from Chiengmai. Among the 38 senile gibbons of the latter series only 6 are entirely free of any signs of disease in their bones or teeth.

It is not as much surprising to encounter these high percentages of wild apes with various pathological conditions, as it is to find that these animals succeed in surviving after having repaired as many as 7 fractures or having suffered from numerous and crippling arthritic changes or multiple alveolar abscesses. Indeed, many of these apes had been afflicted with all these conditions in varying degrees, yet managed to live well nourished until shot. It is also mentioned here that nearly all the gibbons autopsied by the writer were heavily infected with filariid worms (Sandground, '38) and many had intestinal parasites as well.

This record of developmental defects and manifestations of disease in a population of wild apes in their native environment contradicts the customary assumptions of the prevalence of normality and health in nature and of the great efficacy of natural selection.

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NOTES

NEW PROFESSOR OF ANTHROPOLOGY

Dr. Morris Steggerda, for some 15 years connected with the Carnegie Institution's Department of Genetics at Cold Spring Harbor, N. Y., has recently been appointed Professor of Anthropology at the Kennedy School of Missions, a division of The Hartford Seminary Foundation, from July 1, 1944. Arrangements have been made whereby one half of his time will be available for his researches. It is believed that such a major appointment in this field of an outstanding investigator in physical and physiological anthropology is unique, at least in this country. The Carnegie Institution is participating in this arrangement. Since the missionaries from this school are assigned to, and from time to time return on furloughs from, such remote places as New Guinea, Assam, Nigeria and Central China, much new data on human genetics and various aspects of anthropology will undoubtedly become available through this new venture.

C. B. Davenport

NEW INSTITUTE OF HUMAN GENTICS

A new institution for the study and application of human genetics has been established at the University of Minnesota. This is the Dight Institute founded on funds left by a Dr. Charles Fremont Dight of Minneapolis who died in 1938. Dr. Dight was a graduate in medicine from the University of Michigan. He held various professorships of anatomy, physiology and chemistry in Syria and New Orleans and was a lecturer in pharmacology in the University of Minnesota Medical School. He was interested in socialization of medicine; took an active part in local politics and showed a principal interest in eugenics to whose development he, in the absence of children of his own, made principal legatee of his savings. The income from the endowment amounts now to about $4,500. The new Institute is under the direction of Dr. Clarence P. Oliver who is connected with the Department of Zoology of the University of Minnesota.

C. B. Davenport

EXPLANATION OF TERMINOLOGY

In my Demographic and Bodily Changes in Descendants of Mexican Immigrants (1943, Institute of Latin-American Studies, University of Texas, Austin), is given information on occurrence of dental caries, namely, absent, slight, moderate, and pronounced categories (p. 51). Inadvertantly, the numerical meanings of the "moderate" and "pronounced" classifications were omitted from the text p. 54). The term "moderate" refers to four to six teeth effected, (i.e., cavity, filling, or loss of tooth) and "pronounced" refers to seven or more teeth affected.

Marcus S. Goldstein

OBITUARY

Dr. J. McKeen Cattell, a charter member of the American Association of Physical Anthropologists, died on Janury 20, 1944, at the age of 83. Besides being the dean of American psychologists, Dr. Cattell was well known to anthropologists for his editorship of the journals Science, The Scientific Monthly, and the American Naturalist, and the biographical directories American Men of Science and Leaders in Education.

Dr. C. B. Davenport, president of the American Association of Physical Anthropologists, died of pneumonia on February 18, 1944, at the hospital in Huntington, N. Y. A biography and analysis of his contributions to Physical Anthropology are being prepared by his laboratory colleague, Dr. Morris Steggerda, and will appear in a subsequent number of this Journal.

THE STATUS OF TEACHING PHYSICAL ANTHROPOLOGY IN COLLEGES IN THE UNITED STATES DURING THE SCHOOL YEAR 1940–1941

In June of 1941 the undersigned sent a questionnaire to 135 institutions to determine the status of teaching physical anthropology in the United States during the school year 1940–1941. The returns have been discussed in the January issue of the Journal of Higher Education. However, the full details are of interest primarily to physical anthropologists and for this reason are presented here.

Tables 1 and 2 list the colleges to which questionnaires were sent. Fifty-one of the 114 colleges which answered the questionnaire offered Physical Anthropology as part of their curriculum; twenty-six of these taught Physical Anthropology as a separate course, and twenty-five taught the subject as part of another course, generally Cultural Anthropology. Twenty of the fifty-one schools had separate departments called "Anthropology"; in eight, Physical Anthropology was taught in the Sociology department; in three schools, in the Zoology department; in two, in the Geology, in one in the Biology, and in one in the Child Welfare department. Eight schools taught the subjects in a combination of departments; for example, part was taught in the Sociology department, and the rest in the Anthropology department. Other such combinations were Sociology and History, Zoology and Geology, and Biology and Sociology.

Table 1 also shows the number of courses in Physical Anthropology taught in each school, and the approximate number of students enrolled in these courses. Column 6 of table 1 shows the status of the courses, when the questionnaire was answered. Twenty-two schools showed an increase in the enrollment of students in Physical Anthropology, seventeen recorded no noteworthy change, and only one mentioned a decrease in enrollment. In six schools an expansion was contemplated in the teaching of this course. In columns 7, 8, and 9 are listed the courses presented in these schools which may be considered related to Physical Anthropology.

Table 2 presents a list of the colleges receiving the questionnaire in which no Physical Anthropology is being taught. The table shows however which of the related subjects are taught.

Earl W. Count,
New York Medical College
Morris Steggerda,
Carnegie Institution of Washington

TABLE 1

Physical Anthropology as taught in the United States in the school year 1941–1942.

NUMBER	SCHOOL	SEPARATE COURSE	COMBINED WITH ANOTHER COURSE [1]	DEPARTMENT GIVING COURSE [2]	NUMBER OF COURSES IN WHICH SUBJECT IS TAUGHT	NUMBER OF STUDENTS TAKING COURSES	ENROLLMENT COMPARED WITH PREVIOUS YEARS [3]	RELATED COURSES: Cultural anthropology	RELATED COURSES: Sociology	RELATED COURSES: Archeology	TEACHER A MEMBER OF A.A.P.A.
1	Amherst College	v		A	1	68	+			v	*
2	Arkansas, Univ. of		v	Z	1	43	v	v	v	v	
3	Arizona, Univ. of	v		A	2	180	+ !				
4	Brigham Young Univ.	v		G	1	10			v	v	
5	Brooklyn College		v	S, A	2	450	+	v	v	v	
6	Buffalo, Univ. of		v	S, A	1	35	v	v	v		
7	California, Univ. of	v		A	3	85	+ !	v	v	v	*
8	Catholic University	v		A	2	13	v	v	v	v	*
9	Chicago, Univ. of	v		A	4	124	v	v	v	v	*
10	Colorado, Univ. of										
11	Columbia University	v		A	3	?	+	v	v	v	*
12	Cornell University	v		Z	2	60	+	v	v	v	*
13	Denver, Univ. of	v		A	6	65		v	v	v	
14	De Pauw University		v	A	2	42	+	v	v	v	
15	Detroit, Univ. of		v	S, H	3	120	+	v	v		
16	Drake University		v	S	1			v	v		
17	Duke University		v	S	1	15	+ !	v	v	v	
18	Harvard University	v		A	?						*
19	Hawaii, Univ. of	v		A	2	60	+	v	v	v	
20	Howard University	v		An		6	v		v		*
21	Hunter College	v		B	2	113	+	v	v	v	
22	Iowa, Univ. of	v		Ch. W.	3	83	+	v	v		
23	Kansas, Univ. of		v	S	1	25	v	v	v		
24	Kent State University		v	S	2	39	+	v	v	v	*
25	Kentucky, Univ. of										*
26	Louisiana State Univ.		v	A	1	175	+	v	v		
27	Miami University		v	Z, G	2	68	+	v	v		
28	Minnesota, Univ. of	v		A	1	15	v	v	v	v	*
29	Missouri, Univ. of		v	A	1						
30	Mount Holyoke College	v		A	1	16	v	v	v	v	
31	Nebraska, Univ. of	v		S	1	20	+	v	v	v	*
32	New Mexico, Univ. of	v		A	1	11	+	v	v	v	
33	New York University		v	S	1			v	v	v	
34	North Carolina, Univ. of		v	S	5	182	+	v	v	v	
35	North Dakota, Univ. of	v		S	1	5	v	v	v		
36	Northwestern University										
37	Notre Dame Univ. of	v		B, S	2	129	v		v		
38	Ohio State University		v	A, S	1	110	+ !	v	v	v	
39	Oregon State College		v	G	1	20	v		v		
40	Oregon, Univ. of		v	A	1	15	v	v	v		
41	Philippines, Univ. of	v		A	1	8	v	v	v	v	
42	Radcliffe College	v		A	4	17	v	v	v	v	
43	Stanford Univ.	v		An	1	6		v	v	v	*
44	Texas, Univ. of	v		A	1	171	—	v	v	v	
45	Tulane University		v	An	1	2	v !	v	v		*
46	Utah, Univ. of		v	A, S	2	278	+ !	v	v	v	
47	Vassar College	v		Z	5?	26	v				*
48	Virginia, Univ. of		v	An	1	65		v	v	v	*
49	Washington State College		v	S	1	30	+	v	v	v	
50	Washington University		v	A	1	500	+	v	v	v	
51	Wisconsin, Univ. of	v		A, S	3		+	v	v	v	*

[1] Generally Cultural Anthropology.

[2] A — Anthropology; An — Anatomy; B — Biology; Ch. W. — Child Welfare; G — Geology; H — History; S — Sociology; Z — Zoology.

[3] Increase = +; Decrease = —; No noteworthy change = v; Expansion contemplated = !.

TABLE 2

Colleges which received the questionnaire but in which no physical anthropology is taught. This table shows which of the related subjects are taught.

MBER	SCHOOL	QUESTION. ANSWERED	NOT AN-SWERED	CULT. ANTHROP. TAUGHT	SOCIOL. TAUGHT	ARCHEOL. TAUGHT	REMARKS
1	Akron, Univ. of	v		v	v		
2	Alabama, Univ. of	v		v	v		Contemplate giving P.A.
3	American University	v		v	v	v	
4	Bowdoin College	v			v		
5	Boston University		v				Catalogue received
6	Brown University		v				Letter and cat. received
7	Bryn Mawr College	v		v	v	v	Next year. Seminar in Anthrop. will consider phys. anthropol.
8	Bucknell Univ.		v				
9	Butler University		v				
0	California, Inst. Technol.	v			v		
1	Colgate University	v			v		School has phys. anthro on its staff
2	Dartmouth College	v		v	v	v	
3	Delaware, Univ. of		v				
4	Emory University		v				
5	Forida, State Coll.		v				
6	Florida, Univ. of	v		v	v		
7	Fordham Univ.	v			v	v	
8	Franklin and Marshall College		v				Catalogue received
9	George Washington Univ.	v			v		Phys. anthrop. is touched upon in Biol.
0	Georgetown Univ.		v				
1	Georgia State Coll.	v		v	v		
2	Georgia, Univ. of	v		v	v		Expansion in anthrop. contemplated
3	Idaho, Univ. of	v		v	v	v	
4	Indiana, Univ. of	v		v	v	v	
5	Illinois, Univ. of	v			v		Formerly phys. anthrop. wa taught; hope to expand cultural anthrop.
6	Johns Hopkins Univ.		v				
7	Lafayette College	v					
8	Lawrence College		v				
9	Lehigh University	v			v		
0	Long Island Univ.	v					
1	Louisville, Univ. of	v			v		
2	Loyola University	v			v		
3	Maine, Univ. of	v			v		
4	Marquette University	v		v	v		
5	Maryland, Univ. of	v			v		
6	Mass. State College	v			v		
7	Michigan, Univ. of	v		v	v	v	
8	Miss. State Coll.	v			v		
9	Miss. Univ. of	v					
0	Montana State Coll.	v					
1	Montana State Univ.	v		v	v	v	
2	New Hamshire, Univ. of	v		v	v		
3	New York, Coll. of City of		v				
4	Niagara University	v			v		
5	Northeastern Univ.	v			v		
6	Oberlin College	v		v	v	v	
7	Ohio University	v		v	v	v	
8	Ohio Wesleyan	v		v	v		
9	Oklahoma Coll. for women	v			v		
0	Oklahoma, Univ. of		v				
1	Penn State College	v		v	v		
2	Pennsylvania, Univ. of	v		v	v	v	Department of anthrop. and archeol.

Table 2 — *(continued)*

NUMBER	SCHOOL	QUESTION. ANSWERED	NOT AN-SWERED	CULT. ANTHROP. TAUGHT	SOCIOL. TAUGHT	ARCHEOL. TAUGHT	REMARKS
53	Pittsburgh Univ.	v			v		"Some mention of P.A. anatomy course."
54	Pratt Institute	v					
55	Princeton Univ.	v					Phys. anthrop. taught in general evolution cours
56	Puerto Rico, Univ. of	v			v		
57	Perdue University	v					
58	Rochester Univ.	v			v	v	
59	Rutgers Univ.	v			v		
60	St. Johns Univ.	v			v		Contemplating work in phys. anthrop.
61	St. Louis Univ.		v				
62	Seattle Univ.		v				
63	S. Carolina, Univ. of		v				
64	S. Methodist Univ.	v			v	v	
65	Syracuse University	v		v	v		
66	Temple University	v		v	v		Phys. Anthrop. touched u in gross anatomy
67	Tennessee Univ.	v		v	v	v	Phys. features of Indian discussed in course "T American Indian"
68	Texas State Coll. for Women	v			v		
69	Toledo, Univ. of	v		v	v	v	Phys. Anthrop. touched upon in Phys. Educati
70	Tufts College	v					Phys. Anthrop. referred in Comparative Anato course
71	Tuskegee Institute	v					No liberal arts courses gi
72	Vanderbilt University	v		v	v		
73	Vermont, Univ. of		v				
74	Washington University		v				
75	Wayne University		v				
76	Wellesley College	v			v	v	
77	Wesleyan Univ.	v			v	v	
78	West Virginia Univ.	v			v		
79	Western Reserve Univ.		v				
80	William and Mary College	v			v	v	
81	Williams College	v		v	v		
82	Wyoming, Univ. of	v		v	v		

ERRATUM

In N.S. vol. 1, page 333, line 1 read "cemento-enamel" instead of "dento-enamel.

LENGTH OF FIRST, TWELFTH, AND ACCESSORY RIBS IN AMERICAN WHITES AND NEGROES; THEIR RELATIONSHIP TO CERTAIN VERTEBRAL VARIATIONS

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INTRODUCTION

It has long been known that variations in the vertebral column most commonly occur at the extremities of the various regions. Rosenberg (1876, 1884) early noted the phylogenetic shortening of the rib-bearing segment of the vertebral column from its cranial and caudal ends, and concluded that diminutive ribs on vertebrae 8 and 19 were indicative of a "progressive" evolutionary tendency. Furthermore, he interpreted large ribs on vertebrae 8 and 19 and ribs associated with vertebrae 7 and 20 to be "regressive" characteristics. Adolphi ('05) demonstrated that a decrease or an increase in the number of ribs at both ends of the thorax rarely occurs simultaneously in the same individual. He described skeletons with a reduction in the size and development of the first ribs, which he considered to be a tendency for displacement of the cervico-thoracic junction in a caudad direction. The same author further observed that in some of these columns other segmental boundaries were affected by morphological variations such as the presence of lumbar ribs and the lumbarization of the first sacral vertebra. Whenever these multiple variations occurred Adolphi noted that they tended to shift the segmental borders concerned in a uniform direction from their normal level. Other columns were described which presented a reduction of the size or number of ribs at the caudal extremity of the thoracic region; additional variations also associated with shifting of the segmental borders in a cranialward direction were noted in these columns. The tendency for one segment to shift cranialward and another segment to shift caudalward was believed to occur very rarely in the same individual. These observations led Adolphi to support Rosenberg's hypothesis that the human thorax is being reduced in evolutionary sequence by loss of ribs from both cervical and lumbar extremities.

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Kühne ('32, '34, '36) using roentgenograms to study the vertebral columns of families and of identical and fraternal twins demonstrated that the tendency of the segmental borders to shift cranially in some persons and caudally in others is inherited; whereas, specific variations, such as cervical or lumbar ribs, are not inherited. Kühne, and Fischer ('33) explained the inheritance of this tendency to shift on the hypothesis of a single pair of allelomorphs; the cranial tendency was dominant over the caudal tendency. However, experimental studies at Brown University by Sawin ('37) and Green ('39) on the inheritance of rib and vertebral variations in the rabbit gave results which these investigators were not able to reconcile with a single pair of Mendelian factors but they did demonstrate hereditary influences which could be modified by selective breeding.

Adolphi ('00) had stated that the first and twelfth ribs are of approximately equal length in the "normal" individual. Fischer and Kühne accepted this and believed that such uniformity might be accounted for by the presence of genes for cranial and caudal shifting in approximately balanced quantities. Kühne therefore classified his material as either cranial-shifting, caudal-shifting, or indeterminate according to several morphological characteristics, among them the relative lengths of the first and twelfth ribs. For example, a column with large first ribs and small twelfth ribs was said to have a cranial-shifting tendency, and one with small first ribs and large twelfth ribs, a caudal-shifting tendency. It was while trying to classify the racial material in the Terry Skeletal Collection by these methods that interest fell upon rib lengths. In order to evaluate subjective opinion, the first and twelfth as well as the occasional cervical and lumbar ribs were measured.

Little attention has been paid to ribs. Only isolated figures on few specimens are to be found in the records. In the English text-books of anatomy it is generally stated merely that the first rib is the shortest of the series with the occasional exception of the twelfth. No figures on rib size were found except in Morris' American text-book where Prof. R. J. Terry ('42) stated a range from 3 to 20 cm. for the length of the twelfth rib. Anderson (1884) published figures of transverse diameters of human ribs, and Adolphi ('05) included the average lengths of the twelfth ribs of eighty-three cadavers from St. Petersburg in his study of the thorax and vertebral column. Kikitsu ('31–'33, '34) and Hibi ('34) measured ribs of Japanese.

This paper presents (1) a study of the length of the first, twelfth, and accessory ribs in American Whites and Negroes, and (2) the

relationship of rib length to the hereditary tendency of the vertebral column junctions to shift as described by Kühne.

MATERIAL AND METHODS

Ribs and vertebrae from 559 adult skeletons chosen at random from the Terry Skeletal Collection of this Department comprise the material. The skeletons are divided according to race and sex as follows: White males, 132; White females, 101; Negro males, 218; and Negro females, 108. Table 1 reveals the age of the material used.

The Whites are older than the Negroes; this difference extends through the entire Terry Collection and is characteristic of the dissecting room material in this area. The racial composition and sources of this collection have been discussed by Terry ('43). The method of preparation of the specimens has been described by Terry ('32) and Lanier ('40).

TABLE 1

Age in years of the skeletal material according to race and sex.

	NO.	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
W M	132	62.5 ± 1.1	12.2 ± 0.7	19.5 ± 1.2
W F	101	63.4 ± 1.6	15.6 ± 1.1	24.7 ± 1.7
N M	218	50.0 ± 1.1	15.9 ± 0.8	31.8 ± 1.5
N F	108	47.7 ± 1.6	17.0 ± 1.2	35.7 ± 2.4

The ribs were measured according to the technique of Martin ('28): the length of the concave inner surface from the sternal end to the most distal point of the capitulum, taken with a steel tape. Ossified portions of the sternocostal cartilage or cartilaginous tips of ribs were not included. Accessory ribs were measured in the same way.

The vertebral columns were classified as cranial-shifting, caudal-shifting, neutral and in rare cases as both cranial and caudal-shifting according to the morphological conditions present at the extremities of the segments. Kühne's criteria ('36, pp. 16–20) were followed closely in making this subjective classification. For example, vertebral columns having one or more of the following selected traits exhibit the cranial-shifting tendency: free ribs on vertebra 7, large costal elements of the transverse processes of vertebra 7, rudimentary ribs on vertebra 19, ribs lacking on vertebra 19, partial or complete sacralization of vertebra 24, partial or complete caudalization of vertebra 29. Selected characteristics from the list of those expressing the caudal tendency are: rudimentary transverse and costal elements on vertebra 7, rudi-

mentary ribs on vertebra 8, long, well developed ribs on vertebra 19, free ribs on vertebra 20, partial or complete lumbarization of vertebra 25, partial or complete sacralization of vertebra 30. Neutral or "normal" columns show no morphological conditions by which they may be classified. Columns which show changes of both categories are rarities and are unexplained. Kühne's use of a "rib index", as obtained from the roentgenogram, was not followed. In this study the ribs were measured as a procedure separate from classifying the column.

The mean rib lengths and other statistical variables were calculated for race, sex, side, and type of shifting. The relationship of the lengths of the first and twelfth ribs was observed by determining the coefficient of correlation according to methods first described by Pearson as presented by Garrett ('35).

OBSERVATIONS

Length. Data for the length of the first and twelfth ribs of the stocks, sexes, and sides are presented in table 2.

TABLE 2

Length in millimeters of ribs, according to race, sex, and side.

First ribs

	RIGHT				LEFT			
	No.	Mean	Standard deviation	Coefficient of variation	No.	Mean	Standard deviation	Coefficient of variation
W M	124	91.7 ± 0.6	6.4 ± 0.4	7.0 ± 0.4	126	91.5 ± 0.6	6.5 ± 0.4	7.1 ± 0.4
W F	85	89.7 ± 1.1	9.7 ± 0.7	10.8 ± 0.8	91	89.2 ± 1.1	10.4 ± 0.8	11.6 ± 0.9
N M	206	90.2 ± 0.6	9.1 ± 0.4	10.1 ± 0.5	202	89.8 ± 0.6	9.0 ± 0.4	10.1 ± 0.5
N F	105	85.5 ± 0.7	7.4 ± 0.5	8.6 ± 0.6	101	85.4 ± 0.8	7.7 ± 0.5	9.1 ± 0.6
				Twelfth ribs				
W M	106	108.1 ± 3.1	31.9 ± 2.2	29.5 ± 2.0	115	107.3 ± 2.8	29.8 ± 2.0	27.7 ± 1.8
W F	70	88.5 ± 4.2	35.0 ± 3.0	39.6 ± 3.3	75	88.5 ± 3.9	33.4 ± 2.7	37.7 ± 3.1
N M	196	111.6 ± 2.0	28.2 ± 1.4	25.3 ± 1.3	204	110.4 ± 1.9	27.2 ± 1.3	24.7 ± 1.2
N F	100	96.4 ± 2.5	25.1 ± 1.8	26.0 ± 1.8	97	94.6 ± 2.6	26.1 ± 1.9	27.6 ± 2.0

These data reveal the remarkable symmetry in the length of the right and left ribs. Since the difference between the means of the two sides in any given category is not significant statistically (i.e. the difference never exceeds three times the standard error), sides are combined in table 3 in order to compare the races and sexes.

The first ribs of White males and females, and of Negro males are approximately the same length. The difference between any two of

these means is less than three times the standard error of the difference. Negro females, however, have shorter first ribs than the other groups and in each case the difference is statistically significant.

The twelfth ribs present a significant difference in length between the sexes of both races, the females having shorter ribs than the males. The twelfth ribs of Negro males are longest and those of White females the shortest. The difference between these two means is more than seven times its standard error (22.5 ± 3.1). The difference between the lengths of the twelfth ribs of White and Negro males is insignificant, as is that between White and Negro females.

TABLE 3

Length in millimeters of first and twelfth ribs, sides combined.

	FIRST RIBS				TWELFTH RIBS			
	No.	Mean	Standard deviation	Coefficient of variation	No.	Mean	Standard deviation	Coefficient of variation
W M	250	91.6 ± 0.4	6.4 ± 0.3	7.0 ± 0.3	221	107.7 ± 2.1	30.8 ± 1.5	28.6 ± 1.4
W F	176	89.5 ± 0.8	10.1 ± 0.5	11.2 ± 0.6	145	88.5 ± 2.8	34.2 ± 2.0	38.6 ± 2.3
W	426	90.7 ± 0.4	8.2 ± 0.3	9.0 ± 0.3	366	100.9 ± 1.7	33.0 ± 1.2	32.6 ± 1.2
N M	408	90.0 ± 0.4	9.1 ± 0.3	10.1 ± 0.4	400	111.0 ± 1.4	27.5 ± 1.0	24.8 ± 0.9
N F	206	85.4 ± 0.5	7.5 ± 0.4	8.8 ± 0.4	195	95.5 ± 1.8	25.6 ± 1.3	26.8 ± 1.3
N	614	88.5 ± 0.4	8.8 ± 0.3	10.0 ± 0.3	595	105.8 ± 1.2	28.1 ± 0.8	26.6 ± 0.8
W&N	1040	89.4 ± 0.3	8.7 ± 0.2	9.7 ± 0.2	961	103.9 ± 1.0	30.1 ± 0.7	29.0 ± 0.7

Racial comparison is presented in table 3 by disregarding sex. The Whites possess longer first and the Negroes longer twelfth ribs; of these differences only that of the first ribs has statistical validity.

The mean lengths of the entire series of first and twelfth ribs (irrespective of race, sex or side) is also given in table 3. The difference between the means of the first and twelfth ribs is 14.5 ± 1.04, which more than excludes the chance factor.

Variability in length of ribs is shown by the standard deviations and the coefficients of variation in tables 2 and 3. White males and Negro females do not differ significantly from each other in variability of the first ribs, but they differ significantly from White females and Negro males by having less variable lengths of first ribs. The lengths of the twelfth ribs vary considerably more than the first in all groups and by amounts exceeding the chance factor. Among twelfth ribs those of Negro females vary least and White females most. The difference here is statistically significant, and also, by a narrow margin, is that

between White females and Negro males. In comparing variability in length of the first and the twelfth ribs of the Whites with the Negroes no difference is apparent between first ribs; there is a significantly greater variation in the length of twelfth ribs of Whites.

Correlation. In order to determine the relationship between rib length and the tendency of segmental regions of the vertebral column to shift it was first necessary to classify the columns as cranial-shifting, caudal-shifting, neutral, or both cranial and caudal-shifting. The percentage incidence of these types is given in table 4.

TABLE 4

Direction of tendency to shift at segmental borders of the vertebral column according to race and sex.

	CRANIAL		CAUDAL		NEUTRAL		CRANIAL AND CAUDAL		TOTAL	
	No.	%	No.	%	No.	%	No.	%	No.	%
W M	58	43.9	55	41.7	18	13.6	1	0.8	132	100.0
W F	51	50.5	32	31.7	18	17.8	0	0.0	101	100.0
N M	90	41.3	90	41.3	35	16.0	3	1.4	218	100.0
N F	62	57.4	34	31.5	10	9.2	2	1.9	108	100.0
Total	261	46.7	211	37.7	81	14.5	6	1.1	559	100.0

The greatest differences are between the sexes. White and Negro males approximate each other closely; the difference between White and Negro females is notable only in the cranial-shifting and neutral groups. Since all of the discrepancies fail to exceed the statistical probabilities of chance it may be assumed that no difference in the hereditary tendencies to vary exists between American Whites and Negroes.

The lengths of the first and twelfth ribs were compared next in the cranial-shifting, caudal-shifting, and neutral categories. (The number in the group showing both cranial and caudal tendencies is too small for statistical analysis and is not included.) These data are in table 5.

TABLE 5

Length in millimeters of first and twelfth ribs in cranial-shifting, caudal-shifting, and neutral columns.

	FIRST RIBS				TWELFTH RIBS			
	No.	Mean	Standard deviation	Coefficient of variation	No.	Mean	Standard deviation	Coefficient of variation
Cranial	487	91.1 ± 0.4	9.4 ± 0.3	10.3 ± 0.3	436	85.0 ± 1.4	29.0 ± 1.0	34.1 ± 1.2
Caudal	392	87.7 ± 0.4	7.0 ± 0.3	8.0 ± 0.3	370	124.0 ± 1.1	20.5 ± 0.8	16.5 ± 0.6
Neutral	148	87.4 ± 0.6	7.2 ± 0.4	8.2 ± 0.5	143	107.0 ± 1.6	18.9 ± 1.1	17.6 ± 1.0

First ribs of cranial-shifting columns are longer than those of either caudal-shifting or of neutral columns by amounts more than three times the standard errors of the differences between the means. The first ribs of the latter two groups are of the same approximate length. The twelfth ribs of these three groups differ in length in each case by statistically valid amounts. The twelfth ribs of cranial-shifting columns are shortest and those of caudal-shifting columns the longest.

The coefficient of correlation (r) between the total number of first and twelfth ribs (938) was calculated: $r = -.34 \pm .03$. The small value obtained for the regression probably indicates an insignificant relationship.

TABLE 7

Incidence and range in length (millimeters) of accessory ribs according to race and sex.

	CERVICAL RIBS					LUMBAR RIBS			
	No.	Skeletons with cervical ribs		No. of c. ribs	Range	Skeletons with lumbar ribs		No. of l. ribs	Range
		No.	%			No.	%		
W M	132	..	..	..	.....	8	6.1	15	16–53
W F	101	4	4.0	6	36–71	2	2.0	4	36–43
N M	218	1	0.5	2	63–76	27	12.4	47	6–113
N F	108	1	0.9	2	42–72	12	11.1	22	15–73
Total	559	6	1.1	10	36–76	49	8.8	88	6–113

The number of cervical and lumbar ribs in the present series is too small for detailed statistical consideration. Their incidence and range in length is given in table 7.

Lumbar ribs occur in 8.8% of 559 cases; most often they are bilateral as are cervical ribs which were found in 1.1% of the subjects.

DISCUSSION

The preceding observations have demonstrated certain racial and sex differences between the lengths of first and twelfth ribs of American Whites and Negroes. The greater variation in the length of twelfth ribs than in length of first ribs has also been shown. That the lumbar end of the thoracic region of the vertebral column is more variable than the cervical junction is also illustrated by the frequent absence of twelfth ribs (3.6% in 559 cases of the present study) compared with first ribs. The latter were present in all cases. The appearance of lumbar ribs is another example of the state of flux in that region (8.8%

in 559 cases). Cervical ribs are found less frequently. In this study there were 1.1% in 559 subjects; Todd ('12) found cervical ribs in 1.16% of 260 cases.

If the Rosenberg hypothesis is accepted, one might conclude from the above data that American Negroes are more "progressive" than American Whites in the tendency for reduction in the size of ribs at the cervico-thoracic region. On the other hand if variation is considered to be an index of the activity of evolutionary processes, the twelfth ribs of Whites are more labile than those of Negroes. However the difference between the length of twelfth ribs of Negroes and Whites in this study is not statistically significant.

It was axiomatic with Kühne (after Adolphi) that the length of the twelfth rib is inversely proportional to the length of the first ('36, pp. 10–11) in columns showing the tendency to shift segmental borders. In the "normal" column where no tendency to shift may be found the first and twelfth ribs were said to approach the same length. In the present series the mean lengths of the first and twelfth ribs are approximately the same only in the case of White females; in all other groups the twelfth ribs are significantly longer than the first including the group of neutral columns.

The negative linear correlation between the length of first and twelfth ribs while small is ten times its standard error and tends therefore to confirm Adolphi and Kühne. However, trying to predict the length of twelfth ribs by inspecting the first and vice versa was concluded to be an unreliable procedure; this conclusion is substantiated by the small correlation values. The accurracy with which a vertebral column may be classified as cranial-shifting, caudal-shifting, or neutral using the lengths of first and twelfth ribs without consideration of other morphological characteristics in the column is questionable. There is a range of variation in the lengths of these ribs which is almost certainly insignificant.

It was found that 84.4% of the columns in the present study showed evidence of a tendency to shift the segmental borders (46.7% cranial, 37.7% caudal). By use of all criteria including rib length Kühne was able to classify as cranial or caudal-shifting 92.7% of the 327 cases he had studied; 7.3% were neutral. There were 58.5% cranial-shifting and 34.2% caudal-shifting columns among Germans in Berlin.

It should be noted that a small percentage of vertebral columns (1.1%) in this study was found to have morphological variants which indicate a simultaneous cranial and caudal-shifting tendency. Fischer ('33) reported 2 in 1000 cases; Steiniger ('38) summarized the litera-

ture finding nine cases. There is no satisfactory explanation for these exceptions.

CONCLUSIONS

The chief findings of this survey of the length of first, twelfth, and accessory ribs in American Whites and Negroes, and of the relationship between rib length and the inherited tendencies of the segmental borders of the vertebral column to shift are as follows:

1. The first ribs of Whites are longer than those of Negroes. The first ribs of White males, Negro males and White females are longer than those of Negro females; there is no difference in length of first ribs in the first three groups. There is no difference in variability in length of first ribs between the races; first ribs of White females and Negro males vary more in length than those of White males and Negro females.

2. There is no racial difference in length of twelfth ribs. Twelfth ribs of males are longer than those of females. Twelfth ribs are longer than first ribs in White males, Negro males, and Negro females. Twelfth and first ribs are of equal length only in White females. Twelfth ribs vary in length more than first ribs, and in Whites more than in Negroes.

3. Cranial-shifting columns have longer first ribs and shorter twelfth ribs than caudal-shifting and neutral columns. Caudal-shifting columns have the longest twelfth ribs.

4. There is no difference in the occurrence of the vertebral types as described by Kühne in American Whites and Negroes.

5. The length of the first ribs cannot be predicted from the length of the twelfth ribs, and vice versa.

6. The incidence of cervical ribs is 1.1% and lumbar ribs 8.8% in 559 subjects.

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ABSENCE OF CORRELATION IN NEW ZEALAND BETWEEN BLOOD GROUPS AND DENTAL DECAY, ALLERGY, AND CERTAIN CHARACTER TRAITS

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Blood grouping, of all the existing anthropological classifications, seems to be the only one based on purely genetic principles. Any relationship therefore, which could be established between blood groups and any other factors, would be of great importance. This has not been possible. As Julian Huxley puts it, "Genes originally associated have become unstuck by crossing and recombination" (Huxley and Haddon, '35). A number of workers have tested for correlation between blood groups and other characteristics, finding either little correlation (Coon, '31; Corvin, '38; Grigorowa, '31; Meyer, '31; Sell, '30) or no correlation (Boyd and Boyd, '37; Geipel, '35; Howells, '33; Ihara and Yanagihashi, '29; Richter, '40; Steffan, '28). The present war afforded me an opportunity to investigate the question further.

Just before their blood grouping was done, 1640 New Zealand soldiers were given a questionnaire on personal history. The purpose of the investigation was explained to the group and after each man had filled in his paper he discussed it with the doctor. Care was taken that no discussion took place between the men before they had answered the questions. The sample investigated was taken from many different units and age groups and was without preselection of any description. The size of the sample is three times the minimum representative number laid down by Allison Davis (Davis, '35).

The sample consisted of 46.0% (754) group "O"; 41.3% (677) group "A"; 9.6% (158) group "B", and 3.1% (51) group "AB". This corresponds to the usual blood groups in this country, judging from the analysis of the blood banks.

The sample was tested for correlation between blood group and dental decay, medical grading, allergic manifestations, and personality traits (Bernreuter, '31; questions 28 — changed, 51, 88, 101) and no correlation was found.

[1] Condensed and revised by William C. Boyd at the request of the Editor.

DISCUSSION

Haldane's summary of the blood groups of half a million persons (Haldane, '40) in Europe shows significant variations according to geographical distributions. It has been proved that factors like hair color and texture, skull and general measurements, skin color and other physical characteristics show preponderances in certain races, but none has ever been found to be linked up with the blood group. On the other hand, combinations of these characteristics are often found, i. e., black straight hair and a marked epicanthic fold in certain Mongolian races. This investigation has failed to prove any connection between the blood group and other factors, but as stated in a leading article in the British Medical Journal ('42) "At the present time very large numbers of blood donors are being enrolled in connection with the various blood transfusion services, and it may be confidently anticipated that a study of the figures will yield important, and it may be unexpected, results."

However, it should be recalled that "' . . . in (a) population sufficiently free from recent mixture to be in genetic equilibrium, no correlation is to be expected between the distributions of two characters, unless they are caused by, or affected by, the same gene.' (The effect of linkage would in general be eventually masked by the effects of crossing over.)" (Boyd, '40, p. 350).

SUMMARY

Blood groups have been related to medical grading, dental decay, and type of personality in a group of 1640 New Zealand soldiers without finding any significant correlation.

I wish to thank the Director General New Zealand Medical Services for permission to publish these notes.

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STUDIES IN THE PHYSICAL DEVELOPMENT OF NEGROES

IV. ONSET OF PUBERTY

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ONE FIGURE

INTRODUCTION

For obvious reasons the study of puberty had to be confined to observations on females.

Though the main purpose of the present study was to determine the time at sexual maturity in Negroes, data on an other race were needed in order to interpret the Negro material. Therefore, Whites were included in the investigation.

The data on Negroes were collected from 1935 to 1940 at the following places, all in or near New York City: St. Benedict's Home, Rye, New York; Colored Orphan Asylum, Riverdale, New York; clinics of Harlem Hospital and also of Harlem Health Center; Harriet Beecher Stowe Junior High School; Y.W.C.A., Urban League and Girl Scouts; Sunday Schools in Harlem. Visits to Negro homes supplemented the survey. Of this material only that from Riverdale Orphanage represents consecutive observations.

The data on Whites were collected in 1938 in the Abraham Lincoln High School, Brooklyn, New York, and represent single observations. To these I have added older consecutive observations on Whites obtained by Franz Boas ('32) from the Horace Mann School and Hebrew Orphan Asylum, both of New York City. However, I have re-arranged his data in accordance with my classificatory system. In this procedure the original records were used.

Information on the time at sexual maturity was considered adequate only if the interviewed person could remember the month during which her first menstruation occurred. Many girls knew the week or the day, so that their age at puberty could be determined. The Colored Orphan Asylum, Riverdale-On-Hudson, N. Y., furnished records containing entries made on the day on which puberty set in. All other data have an error not exceeding 1 month. Every person underwent a cross-examination by myself and a female or male assistant. The subject's

date of birth was checked and she had to give her reasons why she remembered the calendar day, the week or the month on which she entered womanhood. This scrutiny accounts for the fact that out of about 7000 individuals questioned but half that number could supply satisfactory information.

The youngest age group interviewed was 11 years old. However, among this particular group were so few who had entered puberty that their number can be neglected in a statistical summary.

The study of these data offers answers to certain specific questions, namely,

1. How does the age at sexual maturation of Whites and Negroes compare when corresponding socio-economic strata are investigated?
2. Is the onset of puberty influenced by race or climate per se?
3. Is there a secular acceleration in maturity among Negroes similar to such a phenomenon noted among Whites? [1]
4. How is the onset of puberty related to the premenarcheal acceleration in growth of the general Negro population?

In view of the interrelation of factors determining the age at puberty, these basic themes recur in the various sections of the present report, one consideration being weighed against another; all of them finally leading up to the problem of environment versus heredity.

CLASSIFICATORY METHOD

In order to avoid the errors due to the fact that many of the younger children become mature later than indicated by the age of observation, or — in the case of continuous observation — of last observation, the material was separated according to the age of the individual at the time of inquiry. As might be expected, such a statistical consideration which heeds the age of the informant, reveals that the average age at puberty changes with the age composition of the group: the older the age group is at the moment of investigation the higher will be the figure expressing the average year of maturity for that age group.

I have tabulated single observations by arranging them according to their ages at the time of observation, and consecutive observations according to their ages at the time when they passed out of the series of those who were observed continuously. The values given in table 1 represent the averages for the total material as calculated on the basis of this procedure.

[1] A preliminary report of my findings on secular acceleration in the onset of puberty among Whites (1930 to 1938) was published by Boas ('41).

Since the present paper was conceived as a comparative racial study, as pointed out in the introduction, the values derived from Whites which form the basis for comparison will be discussed first. The data on Whites are presented in table 2 and those on Negroes in table 3. At the bottom of each column of table 2 and 3 the reader will find next to the average age of maturity the standard deviation for the respective racial or socio-economic group. These total averages can be used as comparable figures for the separate strata of population, both Whites and Negroes. It must be emphasized that the uncorrected total averages correspond to the data as usually given in which the age of the informants at the time of observation is not specified. As has been shown, however, the correction for age of observation is necessary because when the observations include many young girls, all those with late maturity are excluded.

TABLE 1

Puberty data of combined Whites and Negroes (3846 cases) with correction for age groups under 16 years.

AGE AT TIME OF OBSERVATION	NUMBER OF CASES	UNCORRECTED VALUES FOR MEAN AGE AT ONSET OF PUBERTY	CORRECTION TO 16 YEARS
12 to 12.9	107	11.97	+ 1.27
13 to 13.9	438	12.47	+ .77
14 to 14.9	852	12.84	+ .40
15 to 15.9	761	13.04	+ .20
16 and over	1688	13.24	0

Table 2 includes averages of puberty dates for 527 cases collected by Franz Boas about the year 1930 (Boas, '32, '33). The new material (3319 cases) collected by the author about the year 1938 occupies the remainder of table 2 and all of table 3. Of the total of 3946 cases 2449 are Whites and 1397 Negroes.

THE ONSET OF PUBERTY IN WHITES

The records of the Horace Mann School (table 2) show that there is no difference in menarche between non-Hebrew (13.09 ± 1.3) and Hebrew girls (13.08 ± 1.2) of the same social class (corrected: 13.28 versus 13.21). This has been pointed out repeatedly by Boas ('40). One must keep in mind that these figures are based on material assembled 8 years prior to that obtained by the writer. This fact is important on account of secular changes in maturity to be discussed later.

TABLE 2

Average age at puberty according to age at time of observation: Whites

Age at time of observation	Horace Mann School (1930)[1] Non-Jewish			Horace Mann School (1930)[1] Jewish			Hebrew Orphan Asylum (1930)[1] Jewish			Abraham Lincoln High School (1938)[2] Jewish			Abraham Lincoln High School (1938)[2] Italian		
	No.	Uncor. Aver.	Cor.[3] Aver.	No.	Uncor. Aver.	Cor. Aver.	No.	Uncor. Aver.	Cor. Aver.	No.	Uncor. Aver.	Cor. Aver.	No.	Uncor. Aver.	Cor. Aver.
12–12.9	6	11.78	13.05	2	11.16	12.43	1	12.75	14.02	20	11.82	13.09	...	....	....
13–13.9	18	11.87	12.64	3	11.20	11.97	8	12.83	13.60	175	12.44	13.21	11	12.53	13.30
14–14.9	36	12.63	13.03	15	12.47	12.87	28	13.27	13.67	431	12.79	13.19	39	12.73	13.13
15–15.9	44	13.06	13.26	17	12.91	13.11	69	13.41	13.61	334	12.91	13.11	67	12.86	13.06
16–19.9	127	13.46	13.46	75	13.37	13.37	78	13.60	13.60	748	12.97	12.97	97	13.11	13.11
Totals	231	13.09 ± 1.3	13.28	112	13.08 ± 1.2	13.21	184	13.44 ± 1.2	13.62	1708	12.85 ± 1.04	13.08	214	12.93 ± 1.07	13.11
1930 vs 1938	(527) 13.21 ± 1.26 (Cor: 13.38)									(1922) 12.86 ± 1.04 (Cor: 13.08)					

[1] Consecutive observations. [2] Single observations. [3] See table 1 for correction factors.

TABLE 3

Average age at puberty according to age at time of observation: Negroes

Age at time of observation	Riverdale Orphanage			Born in South; Puberty in North			Born in North; Puberty in North			Puberty in W. Indies		Born in W. Indies; Puberty in North		Born in South; Puberty in South		Better Class; Born in North		
	No.	Uncor. Aver.	Cor. Aver.	No.	Uncor. Aver.	Cor. Aver.	No.	Uncor. Aver.	Cor. Aver.	No.	Uncor. Aver.	No.	Uncor. Aver.	No.	Uncor. Aver.	No.	Uncor. Aver.	Cor. Aver.
12–12.9	9	12.08	13.35	18	11.86	13.13	48	12.10	13.37	..	....	.	....	...	....	3	11.75	13.02
13–13.9	23	12.74	13.51	65	12.42	13.19	124	12.60	13.37	..	....	.	....	...	....	11	12.30	13.07
14–14.9	23	12.70	13.10	88	13.03	13.43	180	12.92	13.32	..	....	.	....	...	....	12	12.75	13.15
15–15.9	30	13.34	13.54	82	13.01	13.21	108	13.28	13.48	..	....	.	....	...	....	10	13.00	13.20
16–19.9	28	13.66	13.66	67	13.11	13.49	60	13.25	13.28	..	....	.	....	...	....	35	13.08	13.03
20 & over	...	....	....	40	14.12		89	13.30		42	13.99	9	14.13	175	13.68	18	12.92	
Totals	113	13.07 ± 1.1	13.46	360	12.99 ± 1.16	13.34	609	12.94 ± 1.10	13.35	42	13.99	9	14.13	175	13.68 ± 1.40	89	12.85 ± 1.14	13.06

The values for the Hebrew Orphan Asylum were also obtained by Boas about the year 1930. This Jewish group has a higher average age of maturity than the better-to-do Jewish (and gentile) children of the Horace Mann School, namely, 13.44 ± 1.2 (corrected: 13.62). The poorer socio-economic status of the orphan children explains their later development. Here is an example of a different mean age of puberty among two groups of similar descent caused by a different income level, i.e., environmental factors.

The similarity of values obtained in the Horace Mann School for non-Jewish and Jewish girls has its analogy in the results arrived at in the Abraham Lincoln High School. The latter material represents native descendants of Hebrew and Italian immigrants. The average age at maturity for the Hebrews is 12.85 ± 1.04, and for the Italians 12.93 ± 1.07 (corrected: 13.08 versus 13.11). Again we find no marked racial difference for a population having a similar socio-economic background.

Since all the Jewish series are comparable on racial grounds and since the different values for the Jewish girls of the Horace Mann School and of the Hebrew Orphan Asylum have been attributed to socio-economic factors, there arises the question of why the Abraham Lincoln High School girls had an earlier average age at puberty than those of the Horace Mann School. As a matter of fact the students of the Horace Mann School are children of wealthier homes than those attending the Abraham Lincoln High School, which is a public school. Why then do the girls of the Abraham Lincoln High School, being an economically less privileged group than those of the Horace Mann School, show an earlier maturity than the former?

The answer to this question is to be looked for in the time interval between the two surveys. The study at the Abraham Lincoln High School was completed about 8 years later than that in the Horace Mann School. During this period the tempo of growth has been accelerated in the population of New York and puberty has set in earlier. This secular change in the rate of development is also borne out by total averages: the mean value for all white girls studied in 1930 is 13.21 ± 1.26 (corrected: 13.38), whereas for all the white girls investigated in 1938 it is 12.86 ± 1.04 (corrected: 13.08).

THE ONSET OF PUBERTY IN NEGROES

Data from the Colored Orphanage, Riverdale-On-Hudson, were obtained between the years 1935 and 1940. The mean age of maturity

is 13.07 ± 1.1 (corrected: 13.46). This value resembles[2] the averages of the white children obtained at the Horace Mann School 10 years earlier. The Negro orphans, though being a sheltered group, are from a very poor stock as compared with the white children attending a private school. How do we explain this almost identical puberty age? Comparative growth curves have shown that the time of adolescence and of the period of maximum rate of growth practically coincide among both races in New York, if they are under similar environmental influences, and that under these conditions the averages of the time of maturity coincide. The premise of the same environmental influences, however, is not present for the Horace Mann children and the children of the Colored Orphan Asylum. It is, therefore, safe to assume that the latter, having been studied about 8 years later than the Horace Mann children, display a secular acceleration of maturity.[3] This interpretation becomes still more convincing on examining the other data on Negro girls investigated about 1938.

Though the information for the poorer class was obtained from girls attending a public school and women attending dispensaries, one must not, a priori, assume that we are dealing with a population belonging to the same socio-economic status. Those raised in the South of the United States (by "South" I mean the states located south of Washington, D. C.) lived under more unfavorable circumstances than those who grew up in the North where welfare agencies could provide for the poor to a greater extent. Furthermore, the series from the North is mainly an urban population while that from the South is predominantly country folk. The Negroes from the West Indies and the Virgin Islands live under the worst conditions from the point of view of nutrition.

Those Negresses who entered womanhood in the South have a later puberty (13.68 ± 1.40) than those born and grown up in the North (12.94 ± 1.10, uncorrected, and 13.35, corrected).[4] Those who reached maturity in the West Indies have the latest average puberty age (13.99).

The series for the Negresses from the West Indies is, unfortunately, very much smaller numerically than the others and contains both the poor and better-to-do-class. Nevertheless, the differences between the ages at puberty are so marked that the maximal maturity age for the West Indies is likely to be significant. As a matter of fact, of the forty-

[2] The corrected value for the Negro orphan children is greater than that of the Horace Mann series.

[3] This can be substantiated by investigations made two and a half decades ago. The girls of the Riverdale Orphanage matured at the average age of 14.3 years between 1910 and 1914 (See Boas, '40, p. 122).

[4] Or, comparing the age group 20 years and over: 13.68 years versus 13.30 years.

two cases thirty poor individuals had an average of 14.15 ± 1.37 (uncorrected value).

The nine cases born in the West Indies and reaching puberty in the North do not lend themselves to a convincing interpretation of any sort. However, the late maturity of this small group (14.13) makes a follow up of this type of population desirable as this may contribute to our insight into the effects of environmental factors.

The data on those born in the South but reaching puberty in the North suggests that migration from the South to the North, which means transplantation of a rural population to urban life, renders the rate of development of the migrants similar to that occurring in the North: 12.99 ± 1.16 (corrected: 13.34); versus 12.94 ± 1.10 (corrected: 13.35).

As it is improbable that migration by itself would exert a beneficial physiological influence on all the migrants, I have used an additional statistical approach to these data. I have compared the values for all women 16 years and over, excluding all children. Thus for 107 cases born in the South and matured in the North, the mean puberty age is 13.49 ± 1.25 (standard error ± .12); and for 149 cases born in the North and matured in the North, the mean is somewhat earlier, i.e., 13.28 ± 1.35 (standard error ± .11).

Does the complexity of circumstances connected with migration exert a retarding influence on the rate of development? Such a phenomenon has been observed among Whites by Schaeffer ('06). Unfortunately, my present material is too small to permit a consideration of the age at the time of migration prior to maturity.

My data on the better-to-do Negro class are scanty; eighty-nine cases altogether. However, the series is statistically valid. The wealthier Negro class shows for all the age groups studied an earlier average than the material obtained from the poorer class of Negroes. The mean average for the total group of the better-to-do Negroes is 12.85 ± 1.14 (corrected: 13.06); and this value matches the figure obtained for the Whites of the Abraham Lincoln High School; namely, 12.86 ± 1.04 for 1922 white individuals (corrected: 13.08). The significance of this similarity will be discussed below.

SECULAR ACCELERATION IN THE ONSET OF PUBERTY

I have compared the Whites studied in 1930 with the Whites investigated in 1938. The former, 527 cases, yield an average puberty age of 13.21 ± 1.26 (corrected: 13.38); the latter, 1922 cases, 12.86 ± 1.04 (corrected: 13.08). The standard error of the difference is ± 0.02 (for the uncorrected values: ± 0.06), so there cannot be any doubt that we

are dealing with a faster rate of development among those studied more recently. Thus, during this period of 8 years there was for the White population of New York City an acceleration in menarche amounting to 4 months (uncorrected; and 3.6 months, corrected).

The Negroes show a similar acceleration. During the past 25 years (1910 to 1914 versus 1935 to 1940) the sexual maturity of the girls at Riverdale Orphanage has speeded up by 1 year and 2½ months (uncorrected; and 10 months, corrected).

RACIAL COMPARISON

When we compare all the Negroes (1397 cases) and Whites (1922 cases) studied recently, we get a mean of 13.09 ± 1.2 (corrected: 13:40) for Negroes as against 12.86 ±1.04 (corrected: 13.08) for Whites. Thus we see that Negroes mature later than Whites.

It must be emphasized that this difference should not be attributed to a racial characteristic per se, for the following reasons: (1) My Negro material, though including one series from the better-to-do class, is derived from strata which are as a whole socio-economically less privileged than the White population. (2) A time factor may, at least theoretically, have influenced the results of the comparison: My Negro material includes women 20 years of age and over at the time of observation in contrast to the series of Whites which does not; in other words, the Negro material represents an earlier born population than the White one and may possibly be less affected than the latter by a recent secular acceleration in sexual maturity. Nevertheless, the poorer socio-economic background of the general Negro population is most probably a decisive element among the causes contributing to the later sexual maturity of Negroes than Whites.

This contention is borne out by the fact that when chronologically as well as socio-economically similar populations of Negroes and Whites are being compared with each other, there is found one and the same average age at onset of puberty. It has been mentioned already that both the better-to-do Negro series and the Whites of the Abraham Lincoln High School (which is a public school) yielded the identical value of 12.8 years, uncorrected, and 13 years, corrected.[5]

[5] As a whole, the living standard of the better-to-do Negro class (a selected group) approaches that of the general white population used here for comparison. The corrected values eliminate any discrepancy caused by the inclusion of older individuals in the Negro series at the time of observation. The birth dates of eighteen girls of the Negro series antedate those of the White series, however. A lesser recent secular acceleration in sexual maturity for the Negro series may therefore be considered. Whether this unknown factor has affected the average for the eighty-nine Negro cases and thereby impaired the validity of comparison with the average of the White series, is an open question. The time of the survey for this Negro series was 1935 to 1936; for the White series 1938.

SEXUAL MATURITY AND THE TEMPO OF GROWTH

A note on familial heredity factors which might affect the onset of puberty among sisters, is appropriate. Boas ('32) has shown that there is a fairly strong positive correlation between the dates of first menstruation of sisters. This correlation may, of course, be in part due to similarity of family environment but probably contains also an hereditary element. The same consideration applies to the rate of growth of siblings. In his study on "The Tempo of Growth of Fraternities" Boas ('35) has given proof for the heredity of the tempo of growth; and in that investigation he also stated: "It might be suspected that similar home environment is a contributory cause to the similarity of the growth curve of members of each fraternity."

Correlating the average age at puberty of the 1397 Negresses discussed here (13.09 $\pm$ 1.2, uncorrected; and 13.40 corrected) with average height values, it can be shown that the premenarcheal acceleration in growth occurs 1 year prior to sexual maturity. This agrees with Boas' findings ('32) on white girls.

Figure 1 represents the annual increment of growth from 9 years on. Curve *a* was obtained from the Riverdale Orphanage and is based on consecutive measurements; curve *b*, a combination of data from that institution and Public School 136, is based on single measurements. The mean height is tabulated for full year intervals, viz. 11–11.99 years. The mean itself therefore falls at 11.5 years. Increments are calculated between points at which the mean falls, viz. 11.5 to 12.5 years. Thus, the point at which the actual increment is assumed to occur would be at the year point, viz. 12 years.

DISCUSSION OF THE LITERATURE

The bibliography on the puberty of Negroes is very small, Roberton (1851) found the mean age at puberty for eighty-six Negroes from the West Indies to be 15 years 7 months, 8 days. He comments: "The black peasant females of the West Indies, and the manufacturing females of Manchester (England) arrive at puberty about the same period of life, namely, soon after completion of the fifteenth year. The more opulent classes of society menstruate at a somewhat earlier age, on the average; which is to be ascribed to no natural difference, but to circumstances."

Roberton was carefully selective in using reliable data sent to him from the West Indies by a group of conscientious investigators; nevertheless, neither the date of birth nor the exact age at first menstruation of many of the individuals studied, could be given with perfect accuracy.

Engelmann ('02) published series containing data on 12402 Negresses. His mean for the poorer class is offered as 14.05 years. He found identical values for the average age at puberty in the poor Negro populations of St. Louis, New Orleans and Baltimore. To the better-to-do school girls Engelmann ascribes summarily in an appendix: 13.20 years.

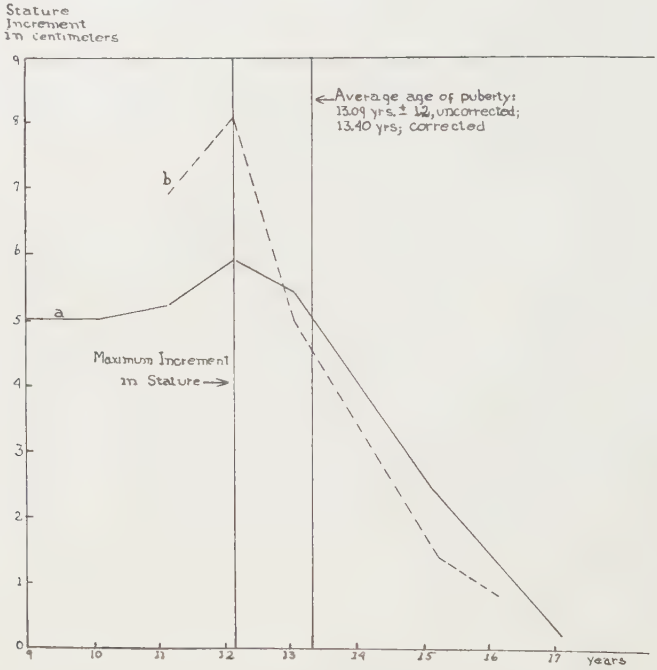

Fig. 1 Relationship of the maximum increment in stature to the average age of puberty in Negro females. Solid curve (a) = Riverdale Orphanage; broken curve (b) = Riverdale Orphanage and Public School 136 combined.

Thus, both of these authors concur in the opinion that a better socio-economic background will cause earlier maturity and that the age at puberty is independent of climate. These conclusions tally with my own. It is highly probable that my averages are earlier than those which Engelmann obtained because the conditions of Negro life have improved since 1902. However, it is an open question whether an uneven age distribution of his informants yielded a spurious average or whether the degree of error of his material (which, in my estimation,

is about 1 year) accounts for the discrepancy.[6] Perhaps both of these factors have affected his results.

Engelmann undertook also a comparison between the onset of puberty among Whites and Negroes in the United States. Comparing the poor class of the two races he found no decisive difference, namely, the mean age of 14.05 years for Negroes and 14.2 years for Whites. Comparing better-to-do school girls he found 13.2 years for Negroes and 13.8 years for Whites. It is strange that his average for poor Whites and Negroes is analogous while that for the better-to-do school girls should show a later onset (0.6 years) for the Whites. Most probably the statistical shortcomings of his method of research, either unverified statements, unequal age distribution of informants, or possibly unaccountable factors of chance, are responsible for the contradiction. In contrast to that of Engelmann our material did not show an earlier puberty of Negroes than that of Whites in the corresponding socio-economic class studied in the same period of time. The reader may compare our total average from the Abraham Lincoln High School (12.86 years for Whites) with the total from the better-to-do Negro class (12.85 years).

By paralleling literature on the puberty of Europeans with that of their offspring Engelmann found an earlier puberty for the latter. Whereas the average was 15.5 and 15.3 years for Germany and Ireland, respectively, the mean in the United States sank to 14.5 years. In France it was 14.5 and in North America 13.4 to 13.7 years. Gould and Gould ('32) confirmed this phenomenon. It is not very far fetched to assume that the improvement of the socio-economic standard of the American born may have caused an acceleration of maturity.

From this point of view it might be interesting to compare European Jews with their American born offspring who belong to the same stock. I quote from Frommolt ('36) some of the averages obtained for East European Jews:

COUNTRY	AUTHOR	JEWS	
		No. of cases	Average
Wilna	Luzyski, '33	127	14.17
Ukraine	Gurewitsch, '29	56	14.71
South Russia	Weissenberg, '09	1273	14.15

[6] To illustrate the blurring out of finer distinctions caused by inaccurate information: if the index or accurracy of a set of puberty dates is, let us assume, 12 months, then a possbile acceleration or retardation of maturity by 3 months might not be discerned. In this event an investigator may fail to find existing influences of the environment on the tempo of development.

The average obtained by Boas ('32) for American born descendants of East European Hebrew immigrants is 13.1 ± 1.2 years (116 cases) for the well-to-do class and 13.5 ±1.1 years (185 cases) for the Hebrew Orphan Asylum children. Both series embrace the age groups from less than 10 years, 3 months to 16 years, 9 months and represent children continuously observed during the entire time. Engle and Shelesnyak ('34) found for American Jews the average 13.5 (250 cases). As was pointed out before, the uncorrected average for the Jewesses of the Abraham Lincoln High School was 12.8 for the year 1938.

Thus we see that the same racial group develops in America much earlier than in Europe; and the acceleration is the more striking the more recent the observations.

The acceleration of the tempo of development of the Negro girls in the Riverdale Orphanage is demonstrated by the following figures:

AVERAGE AGE AT MENARCHE	IN THE PERIOD OF
14.3 years	1910–1914
13.3 years	1920–1924
13.07 years	1935–1940

The acceleration of development of a population which has an opportunity of growing up in a better environment than the preceding generation is a universal phenomenon. Wretholm (Ploss and Bartels, '27) observed that when the nomadic Lapps migrated from their mountainous place of origin to the Swedish towns the average age of puberty became earlier and similar to that of the Swedish girls. Morro (1897) noted that country girls around Turin reached puberty about a year later than those in the city.

It is not surprising that recent investigators have observed a general tendency toward an earlier appearance of puberty during the past decades. I give the following data from G. Frommolt ('36, pages 8, 13, 14, 91): Skerlj obtained in 1935 for Norway the average of 14.39 (in Oslo) and A. Schreiner in 1924 the average of 14.57 while Schjoenberg in 1897 found the mean to be 15.4 in urban and 15.9 in rural populations. Bolk, whose data were not given in round years but considered the months and therefore are more accurate than most, found in the Netherlands that the daughters had their puberty 1 year, 3 months earlier than their mother. Stein found that women who entered puberty before 1880 yield the average of 15.7 and those born after 1900, the average of 14.8 years.

In this connection I should like to quote C. H. Stratz ('22) whose correlation between onset of puberty and socio-economic level shows

for Bavaria strikingly dissimilar averages, namely, for the upper class, 12.9; for the middle class, 14.4; and for peasants, 16.4.

In view of all these findings we must attribute the accelerating tempo of bodily development to the improvement of socio-economic conditions.

This analysis of the literature does not make any claims of being an exhaustive review of all available references. On account of faulty methods of collecting data, in view of inadequate methods of statistical arrangement, and also for the reason that the socio-economic standard at the places of gathering data is nowhere exactly the same, there are many contradictory figures on the onset of puberty. We are mainly concerned here with basic, unchallengeable facts in so far as they are brought out by the study of the material under discussion.

In order to support the unfounded contention that inherent racial peculiarities might account for the difference at onset of puberty some authors [7] point to the earlier age of maturation of Jewesses as compared with the respective "host nations." In America such a difference does not exist. A sociological interpretation may help us to comprehend this issue. In the United States the modes of life of native Jews and gentiles resemble each other much more than that in Eastern Europe of the past decades. When comparing the onset of puberty between Jews and Russians, Weissenberg ('09) emphasized the predominance of urban individuals for the Jewish series. Moreover, it is a tradition of Jewish parents all over the world to afford their children the best possible home care even at the expense of self-deprivation. Therefore, one might assume a somewhat better nutritial status in Jewish homes than in those of their gentile neighbors. It seems to me scientifically unjusified to underestimate this environmental factor and to credit its effect to an illusory racial disparity.

The following bears repetition: any comparison between older and more recent studies is complicated by two factors; first, the element of accelerated development in the series investigated more recently, and second, the difference in the socio-economic character of the various populations. To illustrate this I cite data from three additional American investigations on Whites. Abernethy ('25) in the Chicago Laboratory Study obtained the mean of 13.5 $\pm$ 1.1 (487 girls); Shuttleworth ('37) in the Harvard Growth Study the mean of 13.0 $\pm$ 1.1 (248 girls) and Simmons and Greulich ('43) in the Brush Study the mean of 12.6 $\pm$ 1.1 (200 girls). The girls from the Brush Foundation Regular

[7] See Frommolt, '36, p. 16, and Klineberg, '35, p. 106, for statistics and comments. Frommolt offers a comprehensive bibliography on the menarcheal age.

Series belong to families described as being above the average in economic status.

Thus it becomes evident that the average age at sexual maturity is a statistical concept which has no actual reality and merely serves (among other criteria) to express the rate of development of a specific generation in a particular environment.

SUMMARY AND CONCLUSIONS

1. A critical review of the methods applied in collecting and discussing puberty data has shown that, unless the number of observations is very large which makes the use of longer intervals permissible, no data should be used in which the data of maturity cannot be accurately determined within the limits of 1 month, and that for children up to at least 16 years a record of the date of observation is essential: for the younger age groups corrections must be made; and the correction for the youngest group exceeds 1 year.

2. Corrected as well as uncorrected values show the following: (a) The Negro population as a whole has a later onset of puberty than Whites. This may be attributed to the lower living standard of the former. (b) In the North of the United States the Negroes mature earlier than in the South. In the West Indies puberty occurs later than in the South of the United States.

3. The higher average ages at puberty in the more southern Negro populations may possibly be explained by the type of nutrition which is poorer in the South than the North and poorest in the West Indies in so far as the Negro is concerned.

4. The age at puberty is not a chronologically stable phenomenon in a population subjected to environmental changes. The age of maturity is linked with the socio-economic status of the respective population and shows similar values for Whites of different origin as well as for Negroes belonging to analogous income groups. The economically privileged strata mature earlier than the underprivileged, irrespective of race or climate. These conclusions are based on an analysis of exact data derived from 2,449 white and 1,397 colored indivdiuals, their totality representing twelve separate population groups.

5. Comparison of earlier records with those presented here corroborates the observation of other investigators that there exists a secular acceleration of the age of maturity. During the past two and a half decades the onset of puberty was accelerated in Negroes by 10 months and from 1930 to 1938 in Whites by 3.6 months. It is possible that such an acceleration in physical development indicates an improve-

ment of environmental factors. However, the elements that cause acceleration are still unknown.

6. The material here presented indicates that in large populations no relation can be established between the time of the onset of maturity and racial descent, but that the environmental conditions exert a strong influence. It must be understood that this does not mean that individually hereditary influences are insignificant. The hereditary constitution of the body is a determining factor in the development of the individual. However, in the large mass of individuals contained in a population so many distinct constitutional types occur that the average constitutional types of populations of varying descent show but very slight differences which are entirely outweighed by the influence of environmental conditions.

7. In the general Negro population the relation between the premenarcheal acceleration in growth and the time at onset of puberty is the same as among Whites.

8. The average age at onset of puberty has only a meaning in relation to a specific type of population within a definite period of time and in a particular environment.

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CHARLES BENEDICT DAVENPORT (1866–1944); THE MAN AND HIS CONTRIBUTIONS TO PHYSICAL ANTHROPOLOGY[1]

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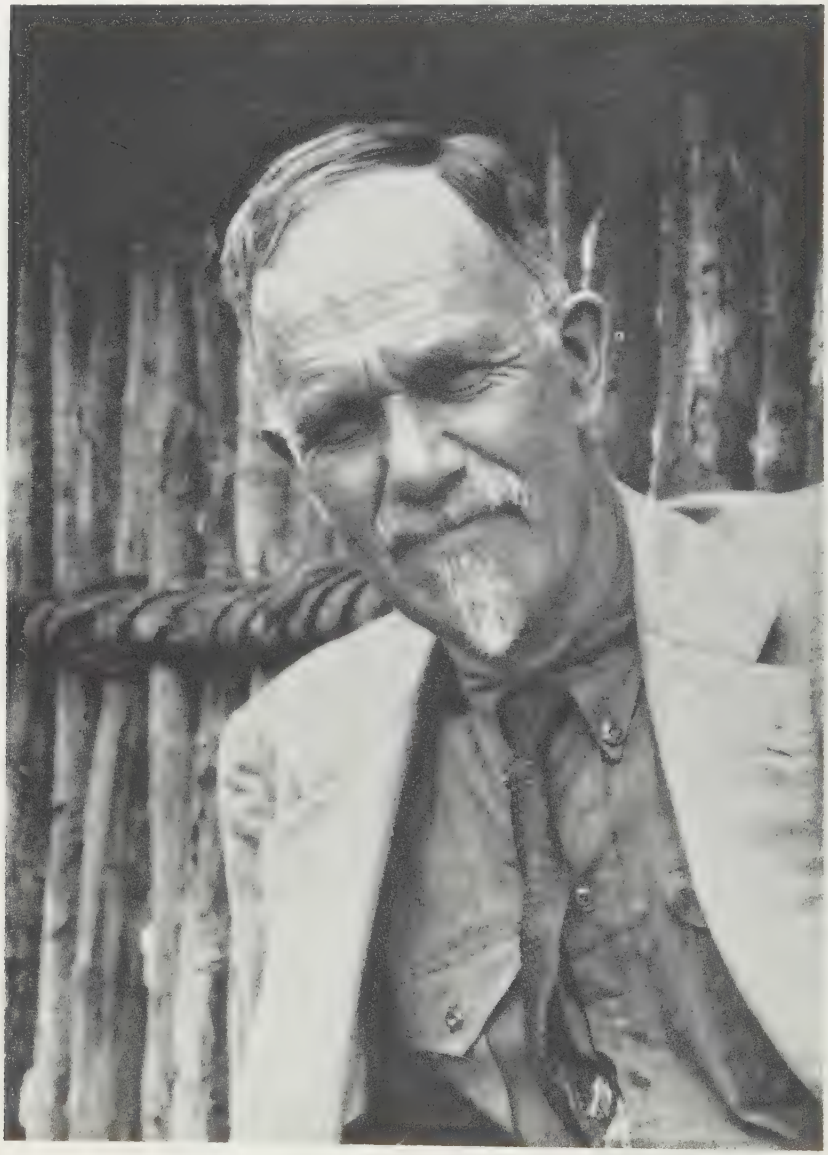
ONE PORTRAIT

In May of 1942 Dr. Davenport wrote: "I have been an American for three-quarters of a century. No, longer than that — for over three hundred years. For this 'I' is composed of elements that were brought to this continent during the 17th century." Dr. Davenport then proceeded to explain what he thought were the predominant characteristics of the American nation; and those who knew him may recognize in them the counterparts of his own special traits. He described Americans as possessing (a) strong individualism and independence, (b) independence of thought, (c) appreciation of knowledge, (d) mechanical skill, (e) love of travel.

One can see these characteristics standing out boldly throughout his entire life and one wonders if he was not unconsciously describing himself as he wrote. Surely he possessed the first three traits to a remarkable degree. Perhaps trait (d) does not characterize our friend as well as do the others, however, he did invent scientific tools; he did act as a surveyor; and he claimed that he was able to see what was mechanically wrong with things although he lacked the patience to make adjustments. The last-named trait, namely, love of travel, is surely appropriate, for Dr. Davenport was an active traveler; he sailed eight times to Europe, he traveled all over the United States, Canada and Mexico, and once to Australia and New Zealand. Concerning one short period in 1916 he wrote in a letter: "My wife and I then became wanderers, going to Chicago to see our daughter Jane settled at the University, then to Battle Creek where I spoke on Eugenics and Religion; then to North Carolina to measure tall people, then to Lake Mohonk where I spoke, then back to Brooklyn from which city I commuted to Cold Spring Harbor." Such nomadic jaunts were frequent during my association with him.

[1] Dr. Davenport was president of the American Association of Physical Anthropologists at the time of his death.



Dr. Davenport possessed another outstanding trait, namely, an ability to overcome difficulties. He said of himself that he was not one who easily abandoned a plan because of difficulties; and in his various projects he experienced an unusual number of them. During World War I he supervised the measuring of one million drafted men. The difficulties of this task were tremendous, but it resulted in the printing of several volumes on Army Anthropology. Similarly, in the establishment of the Cold Spring Harbor Whaling Museum there were obstacles which to most people would have seemed insurmountable; but the tenacity that Dr. Davenport showed in the accomplishment of this project was again conspicuous. That Dr. Davenport wished to instill into others that capacity to overcome obstacles may be seen in his remark when the writer left on his first field trip to Jamaica, B.W.I. He said: "Now I know that you will have all kinds of difficulties, but I don't want to hear of them. All I must know is, can you bring back the data?" This remark seems contrary to his kindly spirit but it accomplished a purpose in that it served as a challenge.

We hear often the phrase, "He was a gentleman and a scholar," and one wonders whether the two terms belong together. They do not necessarily. In the case of Dr. Davenport, however, we can justly use them both, for he had the qualities of an ideal gentleman, and his record testifies to his scholarship. He was kindly, considerate of the viewpoint of others and children liked to ask him questions. It must also be said of him that he always searched for and found at least some good attribute in every individual. Very rarely did he talk of people's undesirable traits. He was enthusiastic, a man of action; his most likely comment concerning a difficult situation was "What can we do about it?"

No doubt, the results of Dr. Davenport's influence will be felt for a long time after his death; but what an influence he has already exerted; in the intensive training of biologists, in the establishment of at least two research institutions, and in the completion of a large number of scientific papers. To understand the origin of this dynamic drive it is necessary to know something of Dr. Davenport's genetic stock; for, as he constantly maintained, the reactions of a particular individual are also expressed in part in the protoplasmic constitution of his relatives. He said, "What a man shall do in his world depends largely upon the instincts and special capacities with which he was born. These are family characteristics."

Thus we may ask, why was Dr. Davenport so kindly, yet at times seemingly curt and short; why was he so shy, and yet often so bold;

affectionate but never demonstrative; limitless in his energy, which he devoted almost exclusively to science; generous with his time for others, yet miserly with time for his own comfort; tactful, easily offended, lonely, at times even feeling inferior to his colleagues; possessed of a rugged constitution, yet, according to Mrs. Davenport, "always getting sick and always getting better." He was intelligent, a born leader, a promoter, a director, an organizer; a zoologist, biologist, geneticist, eugenicist and anthropologist. For answers to these questions and an explanation of the qualities we saw in him, we can look to his own writings concerning himself and his relatives.

EARLY LIFE AND EDUCATION

Charles Davenport was born at Stamford, Connecticut, in his ancestral home on Davenport Ridge, on June 1, 1866. Although his father, Amzi Benedict Davenport, maintained a home in Brooklyn, each year in May the family came to the country where they remained until November. His father, a school teacher and real-estate man, was also interested in agriculture. At their summer home he cultivated formal gardens and operated a general farm, where his son Charles spent much time in studying birds and flowers. The father was actively interested in the church, as were his ancestors before him, dating back to the time of the famous Rev. John Davenport who came to this country in 1637. The father also displayed a keen interest in genealogy and was the author of a book called "The History of the Davenport Family". Dr. Davenport's mother, Jane Joralemon Dimon, was the granddaughter of Teunis Joralemon, merchant, shipowner and judge in Brooklyn in its early days. Dr. Davenport's brothers and sisters were likewise people of affairs. The oldest brother, Henry, founded the Home Title Insurance Co. of Brooklyn; a brother James was a judge in New York; a third brother, just deceased, was Rev. William Davenport, who founded and became head of the Italian Settlement Society of Brooklyn; a sister, Frances, was a historian with the Carnegie Institution; and one of his two half brothers was a lawyer, the other a merchant. All of the brothers, like Charles, were great walkers, spending much time in long, strenuous hikes. All seemed shy, yet with a shyness that turned almost to aggressiveness at times.

Dr. Davenport states that before the age of six he was given a new reading and spelling book, which he prized particularly. At the age of seven he began reading the New Testament and completed it within a year. He said that he had no formal schooling until he was thirteen, being taught by his father during those early years. He tells us that

he spent much time in his father's real-estate office as an errand boy; it was here that his father heard his recitations in grammar, arithmetic and American history. While working his arithmetic problems, he listened to his brother recite lessons in geometry. He relates that his father's favorite pastime was to hear his children parse sentences, adding: "I grew to be a famous parser." During his adolescence he became deeply interested in birds. He enlisted the services of his friends and relatives in various places to help him record their habits and migrations. When he was thirteen he wrote and edited a little paper, which he called "The Twinkling Star" and which sold for 3 cents a copy. At this age he entered the Brooklyn Polytechnic Institute (November 26, 1879), where he partially supported himself by continuing to work for his father. In the Institute Charles specialized in mathematics, often ranking highest in his class and achieving grades from 90 to 95%. Here he became chief editor of the school magazine, "The Polytechnic". During one summer he was a newspaper reporter for the "White Mountain Echo" in Bethlehem, New Hampshire. It is of interest to note that his detailed diaries of the days at the Institute include accounts of financial transactions, involving the loan of a few cents to this or that classmate, and that they also record the architectural plans of the classrooms, the purchase of French and German grammar books, and his correspondence with members of the American Society of Naturalists and the American Ornithological Union. In all these details the boy Charles was meticulous. He was a hard worker during these early school days. The diaries show that he often stayed up until 2 o'clock in the morning to complete his assignments. The same driving spirit was apparent throughout his life, and all who knew him can testify to this capacity for hard work.

He graduated from the Institute in 1885 with a B.S. degree. To earn the necessary funds for entrance to Harvard University, he made use of his technical skill and became a surveyor for the Duluth, South Shore and Atlantic Railroad. In this capacity he spent about a year (1887) in the Michigan woods, experiencing events which he used constantly throughout his life as illustrations in his writings.

In 1888 he entered Harvard College in the Biology Department, which was under the direction of Alexander Agassiz. Dr. Davenport studied under the immediate direction of Dr. E. L. Mark. During his Harvard days, he continued to keep his meticulous records of small loans, of the names of his classmates, and, later, of the social activities of his immediate colleagues and students. Many of the names of these students and colleagues, as found in his diaries, now appear in Who's

Who, and among the noted names in American Men of Science. Among them were C. C. Adams, F. Benedict, W. B. Cannon, W. E. Castle, J. H. Gerould, H. S. Jennings C. A. Kofoid, F. T. Lewis, A. G. Mayor, G. G. McCurdy, H. H. Newman, G. H. Parker, H. S. Pratt, P. Sargent, F. Smith, H. B. Ward, C. W. Woodworth and R. M. Yerkes.

After graduating from Harvard in 1889 he remained as an instructor in Dr. Mark's department until 1899. While a graduate student at Harvard he won the Thayer Scholarship for the years 1890 and 1891. He left Harvard in 1899 to become an Assistant Professor of Zoology at the University of Chicago. During this time (1898–1924) he was also Director of the Biological Laboratory of the Brooklyn Institute of Arts and Sciences at Cold Spring Harbor. About 1902 he was one of many who submitted plans for a biological department in the Carnegie Institution of Washington. In 1903, at the request of the trustees of the Carnegie Institution, he submitted a more detailed plan for this laboratory which was accepted. He then organized the Station for Experimental Evolution which was opened in 1904, with Dr. Davenport as Director. In 1918 the name of the Station was changed to Department of Genetics; and Dr. Davenport remained its Director until his retirement in 1934. In 1910 he established the Eugenics Record Office and 2 years later the Eugenics Research Association. He once wrote that he had never lost a position. Ineed, his record shows that he held only five positions in a long lifetime.

In 1890, at the age of twenty-four, Dr. Davenport published his first scientific writing, and thereafter, for the next 54 years, he averaged more than eight papers a year, with a total of at least 439 written contributions — nineteen of which may be classified as books.

ANALYSIS OF HIS WRITINGS

I have divided the 439 scientific contributions of Dr. Davenport into seven groups: (a) General papers (83 in number). These include annual reports, adresses, announcements of programs, histories of institutions, etc. (b) Zoology (57). Zoology was Dr. Davenport's first interest, and from this basic foundation all of his later specializations arose. (c) Genetics, Eugenics and Human Heredity (153). Although these constitute the bulk of his papers, it is difficult to form a dividing line between this group and the zoology and anthropology papers. (d) Anthropology, including Growth and Development. It is this group of his writings which will be the subject of discussion in the

remainder of this article. (e) Reviews of books and pamphlets (33) These thirty-three papers by no means represent his full output in this respect; for between the years 1916 and 1938 Dr. Davenport edited or assisted in editing a magazine called Eugenical News which contained numerous articles and reviews written by him but were for the most part unsigned. (f) Obituaries and biographies. There are twenty-one of these, and one characteristic of all is the consistent stress laid on the heredity of the person concerned. See particularly that concerning Dr. E. L. Mark [2] and Dr. H. S. Jennings.[3] (g) Articles defending his publications. There are six of these papers and they illustrate another characteristic Davenport trait. If he considered the criticisms of his writings too severe, he often wrote a rebuttal, any one of which makes very interesting reading.

Before discussing Dr. Davenport's contributions to anthropology, I should mention two isolated facts that indicate the broad range of his biological interest. In 1903 he published a paper called "Ecology of the Cold Spring Sand Spit." Thus Dr. Davenport's scope of interest took in the earliest development of the now promising field of ecology. Dr. V. E. Shelford of the University of Illinois did his first research under Dr. Davenport's direction. In the field of dental research, it was Dr. Davenport who wrote the first article in volume 1, issue 1, of the Journal of Dental Research, emphasizing the role of heredity in dentition. Curiously enough, during the 25 years which followed, very few references have appeared in this Journal emphasizing the role of heredity; but the time may come when its importance will again be stressed.

ANTHROPOLOGY

It is convenient to divide this section of Dr. Davenport's writings into five parts, namely, (a) Growth, (b) Races and Race Differences, (c) The technique of Anthropometry and Statistical Methods, (e) Army Anthropology, and (f) Human Heredity and Eugenics. Each of these subjects bears directly on the field of anthropology.

Growth. It is natural for a zoologist to write on the topic of growth and development. In 1898 he wrote a paper called "The Role of Water in Growth." This he considered one of his most influential papers, for it "stimulated more persons to investigations in this field than any of

[2] Edward L. Mark, Bios, vol. 10, pp. 69–82, 1939.

[3] Dr. Herbert S. Jennings' Research. Johns Hopkins Alumni Bull., vol. 24, pp. 822–26, 1922.

my other papers.'' In 1898 he published a two-volume work entitled ''Experimental Morphology'', which discussed the effect of chemical and physical agents upon protoplasm. After this fundamental beginning he put aside his studies on growth for nearly a quarter of a century and devoted himself to the study of heredity in poultry and man. In 1922, however, his interest turned again to growth. In that year he published ''Normal Changes in Body Build During Development'', and in the 20 years that followed he wrote thirty-five papers pertaining to growth, chief among which are: ''The Post-natal Growth of the Nose,'' ''The Post-natal Development of the Head'', ''Growth Curves of Infants'', and ''Development of the Human Foot''. Much of this material was gathered at the Babies' Hospital in Brooklyn, and at Letchworth Village, an institution for the feebleminded. He was always eager to establish rates of growth, and his attention was directed at various times to the actual increment of an object in terms of seconds.

Dr. Davenport early recognized the importance of quantitative methods. In 1901, in a paper called ''The Statistical Study of Evolution'' (Pop. Sci. Mo., vol. 59, p. 447), he wrote: ''But the history of science in general justifies the prediction that biology too will in time use chiefly quantitative methods in studying processes.'' From then on he measured and counted everything: University of Chicago students, Pecten shells, the veins in the wings of chinch bugs, the petals of buttercups, the length of femurs, or the weights of babies. Everything was placed on a quantitative basis.

In this field of growth he expounded his index of body build, which is weight divided by the square of stature. He claimed that he introduced the term ''auxology'', which was incorporated in Webster's Dictionary in 1935.

Races and race difference. Dr. Davenport believed that human beings might well be classified into groups called races, and furthermore, he considered that these races do differ in mental capacity. In all fairness, let him define race as he saw it: (The Effects of Race Intermingling, p. 364) ''A race is a more or less pure bred 'group' of individuals that differs from other groups by at least one character, or, strictly, a genetically connected group whose germ plasm is characterized by a difference, in one or more genes, from other groups.'' Concerning the ways in which human races differ from one another he had much to say. For example, he would point out that dogs differ in innate instincts and mental traits, but that humans, in the thought of many, may be exceptional in this regard. He then proceeds to give his evidence to

the contrary, and remarks that we are driven to the conclusion that there is a constitutional, hereditary, genetical basis for the differences between two races (Negroes and White) in mental traits. In his study "Do Races Differ in Mental Capacity?" (p. 89) he writes: "The conclusion that one may draw from these experiences is that there are differences in the sensory and intellectual fields between different races of mankind."

This idea was a dominant one in his mind, and several of his contributions concerned the "races" of mankind. Into this category falls his Race Crossing in Jamaica, as well as his papers on "Skin Color of Mulattos", "Skin Color of the Races of Mankind", and "The Physical Anthropology of Australian Aborigines and Black-White Hybrids".

Another of Dr. Davenport's ideas in regard to race concerned so-called "disharmonies" due to race crossing. He wrote much on this topic, but the following paragraph from an early lecture on "The Effect of Race Intermingling" gives a good summary of the basic thesis. He said (p. 366):

Turning to man, we have races of large tall men, like the Scotch, which are long-lived and whose internal organs are well adapted to care for the large frames. In the South Italians, on the other hand, we have small short bodies, but these, too, have well adjusted viscera. But the hybrids of these or similar two races may be expected to yield, in the second generation, besides the parental types also children with large frame and inadequate viscera — children of whom it is said every inch over 5′ 10″ is an inch of danger; children of insufficient circulation. On the other hand, there may appear children of short stature with too large circulatory apparatus. Despite the great capacity that the body has for self adjustment it fails to overcome the bad hereditary combinations.

Again it seems probable, as dentists with whom I have spoken on the subject agree, that many cases of overcrowding or wide separation of teeth are due to a lack of harmony between size of jaw and size of teeth — probably due to a union of a large-jawed, large-toothed race and a small-jawed, small-toothed race. Nothing is more striking than the regular dental arcades commonly seen in the skulls of inbred native races and the irregular dentations of many children of the tremendously hybridized American. To sum up, then, miscegenation commonly spells disharmony — disharmony of physical, mental and temperamental qualities and this means also disharmony with environment. A hybridized people are a badly put together people and a dissatisfied, restless, ineffective people. One wonders how much of the exceptionally high death rate in middle life in this country is due to such bodily maladjustments; and how much of our crimes and insanity is due to mental and temperamental friction.

The technique of anthropometry and statistical methods. Perhaps Dr. Davenport's greatest contribution to physical anthropology consisted in his untiring efforts to establish a system of checking. In the field of anthropometry Dr. Davenport and Dr. Hrdlička were colleagues, but they differed fundamentally in their treatment of data. Dr. Davenport used statistical mathematics, whereas Dr. Hrdlička confined himself to the arithmetic of the mean. Both strove for perfection in the technique of anthropometry, but here again they differed. Dr. Hrdlička claimed that his technique, if learned correctly, was final, and that there could be no question about it. Dr. Davenport maintained that the personal error in measuring was so great that a system of checking and re-checking was absolutely necessary. This is what he says:

> It is one thing to take measurements and another thing to take significant and comparable measurements. Children are restless objects and the body is very flexible so that the difficulties of precise measurements are very great. Also, the landmarks which one uses are often difficult to find, embedded as they often are, in muscle and fat. At best the measurement secured is a more or less close proximation to the true value. Sometimes several measurements are required immediately following each other in order to estimate which is the best measurement of a given dimension.

Dr. Davenport's booklet, Anthropometry and Anthroposcopy, is complete and handy. His paper on "The Critical Examination of the Physical Anthropometry of the Living", and his various efforts in behalf of the establishment of standardization committees, testify to his appreciation of the pitfalls of anthropometry. In the entire field of biometry Dr. Davenport stands as a leader. His book Statistical Methods, published first in 1899 and subsequently revised in 1904, 1914 and 1936, established his interest and authority in this field. In 1937 he published a paper entitled "An Improved Method for Measuring Head Features", describing an instrument called a depth measurer by means of which dimensions not previously considered could be measured.

Army anthropology. During the years 1918 and 1919 Dr. Davenport was a Major in the U. S. War Department, in the office of the Surgeon General. At that time he published seven papers which dealt with army anthropology, totaling 3273 pages of printed matter. These include: "Army Anthropology", "Defects Found in Drafted Men", and "Physical Examination of the First Million Draft Recruits", as well

as some shorter but exceedingly important discussions on the comparisons of the incidence of various diseases in different races. The data he put on record regarding the army men in 1918 will be a source of ready comparison with those gathered on the army of World War II, and their importance will be felt for generations to come. A few years after the last war, one of Dr. Davenport's daughters said to him: "And what did you do in the war, father?" His answer was: "I fixed it so that the uniforms would fit in the next war."

Human heredity and eugenics. What Galton did for England in the field of Eugenics, Davenport did for America. He was America's leading eugenicist. He founded the Eugenics Record Office, now called the Genetics Record Office, which has on file great volumes of source material relating to human heredity and eugenics. He was instrumental in starting the late Dr. H. H. Laughlin on his work in eugenics, which specialized in questions of immigration and sterilization. Dr. Davenport's writings dealing with eugenics number 33. His chief interest was human heredity, and one might say that all of his work in genetics was in this field with the exception of his early work on poultry and sheep. His papers on human heredity number 67, the most important of which deal with goiter and otosclerosis. His earlier work on the inheritance of skin-, eye-, and hair-color, and also hair form, is perhaps better known and more often quoted; but not necessarily more fundamental.

There are also papers on the inheritance of stature, longevity, disease, bone defects, twin births, mental disorders, albinism and pellagra. He also wrote on sex linkage in man as well as on chromosomes and endocrines.

What more must be said of this man of science? I recorded earlier that Dr. Davenport was a tireless worker; no one would wish to deny this; he accomplished a great deal, and much of that which he did will continue to bear fruit. He has been criticized for publishing his ideas too hastily. I doubt whether he ever felt this to be true, although some of his most devoted students and colleagues were among those who held this opinion. His writings are not theoretical; no great biological theories are expounded in them. Rather, he came quickly forward with each bit of scientific knowledge, and then hastened back for more. He wrote his papers alone; of the 400 or more papers, less than 10% were written with his colleagues as collaborators. The men who worked under his direction were always encouraged to develop into

independent investigators; they may have been influenced but not dominated by the Davenport spirit.

Earlier in this paper I mentioned an incident from my association with Dr. Davenport which had influenced me a great deal. I will add two more of his statements which may be helpful for a better understanding of the man. He said: "Every table, chart, or manuscript sheet should be so well labeled and identified that were it to be detached from the manuscript, it still could be read intelligently and serve a purpose." Again: "The teaching of anthropology without a laboratory is like teaching baseball without a baseball diamond." On the occasion of his seventy-fifth birthday one of his anthropological colleagues wrote to him, saying: "It must be a source of great pride to you to look back and to say justly, 'I have labored in the vineyard and have reaped a goodly harvest.'" After his death, another colleague wrote to the writer, saying: "Dr. Davenport illustrated in a perfect manner what was meant by that phrase 'A man without guile'".

In March of 1885 Charles Davenport wrote a 10-page letter to his father, thanking him for his support during his days of the Brooklyn Polytechnic Institute and offering his services for the summer. The outline of work which he proposed (to his father) typified his interest in biology, and the way in which he planned to allot his time was typical of him:

> The summer vacation will include about 10 days in June, 31 days in July, 31 in August, and 10 in September, making a total of 82 days, or 70 working days. To allow a daily average of 14 hours of work during this time, is to give us nearly one thousand hours of work. The work I have laid out will, upon adding up, be found to occupy about 750 hours or $\frac{3}{4}$ of this time. I am well aware that I am laying out no easy work for myself, and one which will require much indoor work, but science is a life study, and I shall try to find my recreation in its study.

Thus, from his earliest days, throughout every moment of his long life, he was constantly occupied with scientific endeavors. Four weeks before he died, he was still in perfect health. At that time he acquired the skull of a killer whale, which was to become an exhibit in the newly-founded Whaling Museum, at Cold Spring Harbor, of which he was Curator. For nearly 2 weeks he cooked and cleaned the skull of this mammal, and during this time he contracted a severe cold. This quickly developed into pneumonia, which proved fatal on February 18, 1944. So lived and died our dear friend, Charles B. Davenport.

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(This list includes less than half of his total Contributions)

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DISTRIBUTION OF THE A_1-A_2-B-O, M-N, AND RH BLOOD FACTORS AMONG NEGROES IN NEW YORK CITY [1]

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Ever since Uhlenhuth ('01, '28) and Nuttall ('04) showed that it was possible with the aid of the precipitin test to distinguish the blood serum of animals of one species from serum of animals of other species, attempts have been made to apply this test for the differentiation of blood of different human races, especially the White and Negro races. While a few reports have appeared in which it was claimed that Negro and White bloods could be distinguished in this manner, the reports are unconvincing and the claims could not be substantiated by other reliable investigators. Moreover, no agglutinogen has been found in the red blood cells that is universally present in one human race but absent from other races. However, as Hirschfeld and Hirschfeld ('19) showed for the first time in the case of the four blood groups, the agglutinogens determining individual differences in human blood frequently exhibit different distributions among races. In this paper we propose to compare the distributions of the various serological properties among Negro and White individuals in New York City.

In the case of the four Landsteiner blood groups, it has been reported that groups O and B are more frequent and group A less frequent among Negroes than among Whites. According to Landsteiner and Levine ('30), among group A individuals subgroup A_2 is relatively more common in Negroes than in Whites. As far as the properties M and N are concerned, however, no significant difference has been observed in the distributions. Landsteiner and Levine ('29) reported that the so-called agglutinogen P has a higher incidence among Negroes, and Landsteiner, Strutton and Chase ('34) have described a rare property of human blood occurring far more frequently among Negroes than among White individuals. Schiff ('40) in tests for the group substances A and B in saliva found that non-secretors occurred more frequently among Negroes than among Whites. In studies on their recently discovered property Rh of human blood, Landsteiner and

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Wiener ('41) found the Rh-negative type to have a somewhat lower incidence among Negroes. On the other hand, Levine ('42) found that bloods reacting negatively with so-called anti-Rh_1 sera are about twice as frequent in Negroes as in Whites.

More recently, it has been found that the Rh agglutinogen is not a single entity but has at least five variants determined by corresponding allelic genes and giving rise to eight types of blood (Wiener, '43b). We have investigated the comparative incidence of these Rh blood types among Negro and White individuals, and we propose to present our findings here, together with some new data on the distribution of the blood groups, subgroups, and M-N types.

MATERIALS AND METHODS

The Negroes who supplied the specimens for the tests have been separated into two series, as follows: One series [new series b tables 1, 2 and 3] consists exclusively of patients from the wards of the Harlem Hospital. In this series, moreover, slight selection was exercised in that blood samples were taken only from individuals without physical traits manifestly indicative of White admixture. The other series of Negroes (new series a) was much more heterogeneous and included patients from the out-patient department and maternity wards at the Jewish Hospital of Brooklyn and the Bellevue Hospital of New York City, no attempt being made at selection.

The control series of Whites was a mixture of different ethnic types, the bloods having been obtained from patients, physicians, technicians, etc., principally at the Jewish Hospital of Brooklyn.

The technique of collecting and testing the blood samples has been described in detail in a previous report (Wiener, Sonn and Belkin, '44).

RESULTS

For the sake of simplicity we shall discuss separately the results of the tests for the blood groups and subgroups, the M-N types, and the Rh types, in the order given.

Blood groups and subgroups. In table 1 are presented our data on the distribution of the Landsteiner blood groups and the subgroups of groups A and AB.

Our findings confirm the higher incidence of groups O and B, and the lower incidence of group A, among Negroes. They also show that within group A, subgroup A_2 is relatively more common in Negroes, although the absolute incidence of subgroup A_2 is slightly lower than

TABLE 1

Comparative distribution of blood groups and subgroups among Negro and White individuals in New York City.

SERIES	NUMBER OF INDIVIDUALS TESTED	FREQUENCIES OF GROUPS							GENE FREQUENCIES [2]				$D = 1 - (p_1 + q_1 + q + r)$	P.E.$_D$
		Group O	Group A			Group B	GROUP AB							
			A_1	$A_{1\,2}$	A_2		A_1B	A_2B & $A_{1\,2}B$	p_1	p_2	q	r		
Negroes														
Previously reported [1]	189	48.1	19.6	.. [1]	6.8	22.8	1.6	1.1	12.2	4.8	14.5	69.4	— 0.9	± 0.6
New series (a)	93	45.2	19.3	3.2	4.3	21.5	3.2	3.2	13.0	5.4	15.2	67.2	— 0.7	± 1.0
New series (b)	138	47.1	15.2	5.8	7.2	19.6	2.2	2.9	9.4	8.9	13.2	68.6	— 0.2	± 0.8
Whites														
Previously reported [1]	1,077	41.7	29.0	.. [1]	8.9	13.9	5.2	1.4	18.1	6.5	10.0	64.6	+ 0.8	± 0.3
New series	562	40.6	30.3	0.3	9.8	11.6	5.9	1.6	20.3	7.5	9.0	63.7	— 0.5	± 0.4

[1] Wiener, A. S., and Sonn, E. B., cited by Wiener ('43a, p. 323). In these studies all group A bloods giving weak or intermediate reactions with absorbed B serum were arbitrarily classified as A_2, all other group A bloods as A_1.

[2] For simplicity when computing gene frequencies, bloods giving intermediate reactions ($A_{1.2}$) were classified as subgroup A_2. Therefore, p_2 actually represents the sum of the frequencies of genes A_2 and $A_{1.2}$.

in White individuals. No individuals of the rare subgroups A_3 and A_3B were encountered in the present study.

One striking finding is the markedly higher frequency among Negroes of individuals of group A giving reactions intermediate between A_1 and A_2. This, incidentally, accounts for a misunderstanding in some of the earlier studies on the subgroups of A. Landsteiner and Levine ('30), working in New York on material containing a high proportion of Negro bloods, reported the existence of frequent bloods of group A giving intermediate reactions in subgrouping tests. Thomsen ('30) on the other hand, in tests carried out in Copenhagen, denied the existence of bloods intermediate between A_1 and A_2. Thomsen believed that his sharper results were due to the special technique he used, but the data of table 1 indicate that the explanation is to be found in the racial differences between the populations studied.

In our opinion, group A bloods giving intermediate reactions represent a special subgroup of A (designated in table 1 as $A_{1\,2}$), due to the presence of a special, qualitatively different agglutinogen A, determined by a corresponding allelic gene. In support of this may be cited our observations on family material, where we found that several individuals in the same family may exhibit the characteristic (Wiener, Sonn, and Belkin, '44).

It will be noted that in table 1 we have listed together bloods of subgroups A_2B and $A_{1\,2}B$. The reason for this is that the reactions of group AB blood with absorbed B sera are somewhat weaker than those of group A blood, apparently on account of the interfering effect of the B agglutinogen. Thus, A_1B blood gives only partial clumping with absorbed B sera which strongly agglutinate A_1 blood. By the same token, since absorbed B sera give only weak or partial reactions with $A_{1\,2}$ blood, they would not be apt to agglutinate $A_{1\,2}B$ blood, and the latter would be classified as A_2B. When determining the gene frequencies, subgroups $A_{1\,2}$ and A_2 were combined in order to be consistent with the method of dividing group AB.

It should also be mentioned that our impression from the reactions of the Negro bloods with absorbed B sera is that a number of gradations exist between A_1 and A_2, though for simplicity we have arbitrarily designated all intermediate bloods as $A_{1\,2}$. This suggests the possibility (among others) that gene A_1 arose from gene A_2 or vice-versa as a result of several step-like mutations rather than a single mutation, and that in White populations the genes for the intermediate varieties of the A agglutinogen have almost entirely disappeared. The fact that the intermediate subgroups of A have lower frequencies than the ex-

treme types, A_1 and A_2, suggests that the genes A_1 and A_2 are probably much less mutable than the genes corresponding to the intermediate subgroups.

The finding that Negro series a has a lower percentage of $A_{1\,2}$ bloods than series b suggests that the former series has undergone more racial admixture with Whites. As will be pointed out later the Rh tests show the effect of racial mixing even more strikingly. A conflicting observation is that the incidence of group B in series a is higher than the incidence of group B in series b. However, in view of the small size of our series, this may well be accidental, and one must also consider that the White population selected as standard may have a different blood group distribution from the population with which the crossing occurred.

TABLE 2

Comparative distribution of the M-N types among Negro and White individuals in New York City.

SERIES	NUMBER OF INDIVIDUALS TESTED	FREQUENCIES OF TYPES			GENE FREQUENCIES		$D = 1-(\sqrt{M}+\sqrt{N})$	P.E.$_D$
		M	N	MN	*m*	*n*		
Negroes								
Previously reported [1]	278	28.4	21.9	49.6	53.2	46.8	— 0.1	± 2.0
New series (a)	94	28.7	28.7	42.5	50.0	50.0	— 7.2	± 3.6
New series (b)	138	29.0	28.3	42.8	50.4	49.6	— 7.0	± 2.9
Whites								
Previously reported [1]	6,129	29.2	21.3	49.6	54.0	46.0	— 0.1	± 0.4
New series	582	28.5	21.8	49.7	53.4	46.6	— 0.1	± 1.4

[1] Cited by Wiener ('43a, p. 326).

M-N types. In table 2 are presented our data concerning the distribution of the M-N types in Negro and White individuals, together with comparable data previously reported. It will be seen that our results, like those previously obtained, do not reveal any significant difference between the two races with regard to the distribution of the M-N types.

Rh types. The studies on the various Rh blood types yielded the most striking and interesting results.

As is shown in table 3, the so-called type Rh, which has an incidence of only 2 to 3% among White individuals, occurred in 24.5% of the Negroes of series a, and in 41.6% in the Negroes of series b. Accordingly this type was from ten to twenty times as frequent in Negroes as in Whites, and probably if Negroes of purer ancestry would have been tested, the difference would have been even more striking. Type Rh_2 is

TABLE 3

Comparative distribution of the Rh blood types among Negro and White individuals in New York City.[1]

SERIES	NUMBER TESTED	FREQUENCIES OF RH BLOOD TYPES							GENE FREQUENCIES[4]						D = 1 - Σ Rh_1	P.E.$_D$
		Neg.	Rh_1	Rh_2	Rh_1Rh_2	Rh_0	Rh′	Rh″	*rh*	Rh_0	Rh_1	*Rh′*	Rh_2	*Rh″*		
Negroes																
Series (a)	95[2]	9.6	30.8	22.3	11.7	24.5	1.1	0	30.9	27.4	21.2	1.7	16.7	0	+ 2.1	± 1.2
Series (b)	138[2]	7.3	21.2	21.9	7.3	41.6	0.7	0	27.0	42.9	12.9	1.3	14.2	0	+ 1.6	± 0.7
Whites																
Series (a)	263	13.3	53.2	13.3	16.7	3.0	. .[3]	0.4	36.6	3.8	43.0	. .[3]	14.0	0.4	+ 2.2	± 1.3
Series (b)	359	11.4	51.2	14.8	19.2	2.2	0.8	0.3	33.8	3.2	42.9	1.2	16.2	0.4	+ 2.3	± 1.1

[1] This table includes, together with a few additional bloods, the data reported in a previous paper (J. Exp. Med., vol. 44, p. 316, 1944).

[2] One blood in each of the two Negro series gave atypical reactions. These bloods were disregarded when calculating the frequencies.

[3] The first series of white bloods was not tested with standard anti-Rh serum, only with anti Rh′, anti Rh_1 and anti-Rh_2, so that type Rh′ bloods in this series were classed together with the type Rh_1 bloods.

[4] The symbol Σ Rh_1 in the next to last column represents the sum of the gene frequencies.

also more frequent in Negroes than in Whites, but the difference here is small. Type Rh_1, on the other hand, is about twice as frequent in Whites as in Negroes, and in conformity with results previously reported (Landsteiner and Wiener, '41), the Rh-negative type was found to be somewhat less frequent in Negroes than in Whites. The comparative distributions of the Rh types among the Negroes of series a and b fit very well with the assumption that series a has undergone a good deal more crossing with Whites than series b.

As has been pointed out in a previous paper (Wiener, Sonn, and Belkin, '44), agglutinogens Rh′ and Rh_1 are serologically related in that both react with anti-Rh_1 sera, though agglutinogen Rh_1 reacts in addition with standard anti-Rh_0 serum. If agglutinogen Rh_1 arose from the Rh-negative type, then gene Rh′ may possibly represent an intermediate stage in the mutation from gene *rh* to gene Rh_1. Similarly, gene *Rh″* may represent an intermeditae stage in the mutation from gene *rh* to gene Rh_2. If these assumptions are correct, then the fact that types Rh′ and Rh″ are much rarer than types Rh_1 and Rh_2 would suggest that genes *Rh′* and *Rh″* may be more mutable, while genes Rh_1 and Rh_2 are presumably stable genes.

SUMMARY AND CONCLUSIONS

Data are presented as to the relative distribution of the four blood groups, the subgroups of A, the M-N types and the Rh types among Negro and White individuals in New York City. Our data confirm the previous reports that groups O and B are more frequent, while group A is less frequent among Negroes than Whites. Subgroup A_2 is relatively more common among group A Negro individuals than among group A White individuals, though the absolute incidence of subgroup A_2 is lower in Negroes than Whites. One interesting finding is that group A individuals of intermediate subgroup are much more common among Negroes than in Whites. No significant difference was observed in the distribution of the M-N types among Negroes and Whites.

The most pronounced serological difference between Negro and White individuals thus far encountered is the difference in the incidence of the so-called type Rh_0. As is shown by our data, even though the Negroes tested had presumably undergone considerable crossing with Whites, the disproportion between the races in the incidence of this type was as high as 10 or 20 to 1. Presumably, tests on full-blooded African Negroes would yield even more striking results. This finding suggests that tests for the Rh blood types might be used as an index

of the purity of a Negro population. Of course, the test has little, if any, value when applied to single individuals.

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PHYSICAL TYPE AND MENTAL CHARACTERS

PRELIMINARY NOTES ON THE STUDY OF THE CORRELATION BETWEEN RACIAL TYPES AND TYPES OF PSYCHOTIC REACTION

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INTRODUCTION

It is with some diffidence that the following article is presented. The work described was undertaken with the strictly limited objective of finding out how promising a field there was for research in the no man's land between anthropology and psychology. But time, financial considerations, and the difficulty of obtaining certain items of anthropometric equipment under war time conditions, prevented the investigation from reaching the state of completion which the author had originally hoped. Nevertheless certain interesting results were emerging and it seems worth while to place them on record.

It is one of the most common beliefs that races differ in mentality. Popular opinion, without knowing what a race is, and without any training in scientific psychology, is certain on the point, attributing to its own group every estimable quality and to its political enemies all that is bad. Scientific investigation of the matter is still unsatisfactory. Usually the cultural backgrounds of the racial types compared have differed so widely that such differences as were found could reasonably be accounted for by differences in the social environment. One can search in vain for any controlled laboratory experiments taking into account physical traits which anthropologists would regard as indicative of racial differences. On the whole, current scientific opinion is best expressed in the statement of Dr. Morant ('39, pp. 150–151):

> We know very little about the association of inborn physical and psychical characters, or about racial differences in inborn psychical characters. The difficulty here is in defining and measuring any traits relevant to the problem considered . . . As far as we know, the body characters used by anthropologists to distinguish races are not associated with any mental characters in individuals. At the same time there may be some racial differences in mental characters and it is probable that there are. These are most likely to be similar in nature to the physical differences.

METHODOLOGICAL CONSIDERATIONS

Before the study of correlations between racial type and mental disorder can be made, we need to know the answers to a number of fundamental questions:

1. To what extent can physical types be classified and defined?
2. To what extent can mental disorders be satisfactorily classified?
3. What other factors are likely to affect the general situation?

The answer to the first problem has been largely dealt with in our papers on the samples from County Antrim and County Derry (see Ulster J. Archaeol.). We found that whether we analyzed the data mechanically without any previous conception of the types we might find or whether we relied on classification by general observation and grouping at sight the results we obtained were essentially the same. As these types agreed very well with the types in prehistoric populations the general scheme of classification seemed satisfactory.

A very high percentage could generally be classified easily. From a a metrical approach we normally utilized over 90%, but on general observation 75% "grouped" was a fairly high figure. One usually compromised between these two percentages; and as work progressed, further elements, accounting for some of the remainder, were gradually being defined. On the whole it was relatively easy to find the differential tendencies between elements — e. g. between the Palaeolithic and Atlanto-Mediterranean dolichocephalics, or between the Beaker and Dinaric brachycephalics, or between the brachycephalics and the Mediterranean types . . . etc., etc. Where precisely to draw the boundary between these types on metrical grounds was in theory at least, rather more difficult. Yet it was noticeably rare to find individuals who were metrically intermediate between any of our abstracted "types." If for example, we had found ten traits characteristic of one type and ten of another, we would scarcely ever find any individual with five of each. More often one would find seven from one and three from the other, or six and four, but "blends" were noticeably uncommon.

In brief, most individuals could be classified into types, and the error caused by a fluctuating boundary would not, it was thought, be so great as to obscure any general correlation between mental characters and physical type, and need not prevent us from drawing valuable conclusions regarding the great majority of individuals who were obviously of distinct types.

On the second question the author does not consider himself really competent to judge. Medical opinion appeared divided. Some held

that for example, manic depressive and schizophrenic conditions could always be distinguished; others said that patients with mixed symptoms were most frequent. But it might be more than coincidence that in those hospitals where the psychoses were claimed to be easily classified the physical types were most distinct, and where the racial material was unpromising from a general classificatory viewpoint psychotic reactions were stated to be mixed. It is certain, however, that much more knowledge about the causes of mental disease, and the mechanisms involved in symptom formation, would be required before a satisfactory classification of mental disorder could be reached. In general, it was accepted that the medical classification as given, for example, in Henderson and Gillespie's text book ('40) would prove satisfactory, and that most cases could be fitted into their scheme.

The third problem was, in theory, the most serious. One could expect a psychotic reaction not to have a simple origin but to be derived from the interaction of three main groups of factors:

(a) Innate constitutional factors.

(b) The experiences of infancy which laid the foundation for behavior in later life.

(c) The demands of the society in which the individual is living, the stress arising from social situations, conflicting value systems, etc.

Most modern psychologists lay much stress on the social environment, and on the values and attitudes which the individual holds. And one of the most promising lines of investigation stressed by the Freudian school is the role of the experiences of early life in the formation of the personality. In brief, before finding out the role of the constitutional factor in determining reactions one might have to make allowances for the environmental situation. At the same time the constant similarity of the types of psychotic reaction from individuals in different countries, under different social systems, from different social strata, suggests that it is in the study of the constitutional factor that the key to the understanding of the psychoses will be found.

In this preliminary study then, the attitude which we took was as follows: it was decided to wade boldly into the problem without worrying overmuch about accuracy of definition, especially in the difficulties of classifying mental disorder. Any attempts at precise, detailed quantitative work would, when so little was known about the field, be a waste of time, and would probably be a hindrance in the initial stages of the work. Only when the problems involved could be seen from the inside, as it were, would precision become practicable.

The plan adopted was as follows: a sample of mental hospital patients was measured (over 100 subjects); these were classified into racial groups in accordance with a scheme previously worked out — and a correlation table of the racial types and types of psychoses was drawn up. From this, certain general ideas suggested themselves and these were checked by further observations in other hospitals.

RACIAL TYPES IN THE POPULATION OF THE NORTH OF IRELAND

This section consists of descriptions of the main physical types which can be distinguished in the population of Ulster. The conception of these types is based mainly on the preliminary statistical analysis of the data collected by Mr. John M. Mogey (measurements of about 700 subjects) and data on over 100 mental hospital patients measured by the author. This anthropometric data was supplemented by a long continued series of observations both on the population at large and in mental hospitals. It was found that, once we knew from our first surveys what points to pick out, general observation and the systematic recording of descriptive data would provide us with much valuable material. In the descriptions that follow I have usually given first of all the main distinguishing characters of the "type"— these are the actual criteria on which the typology of the population was first worked out. To these have been added further descriptive details ascertained by comparing individuals who had these main distinguishing traits, with one another and with other types. Certain of these features were then used in later work as criteria for classification. Where there is any difficulty in distinguishing between types, — where two elements might easily be confused, the main distinguishing characters have been outlined. The classificatory scheme is given in Table 1.

TABLE 1

Racial types in Northern Ireland: classificatory scheme

- Brachycephalics
  - Beaker
  - Dinaric
- Mediterranean
  - Dinaricised Mediterranean
  - Atlanto-Mediterranean
  - Basic Mediterranean
  - Derived forms (infantile)
    - a. dolicho
    - b. mesocephalic
- Neanthropic (Upper Palaeolithic)
  - Hyperdolichocephalic
  - Mesocephalic — large headed
  - Miscellaneous mesocephalic forms
  - Derived forms
  - Borreby survivors
- Nordics
  - of Beaker origins
  - of Palaeolithic affinities
  - Blond Atlanto-Mediterraneans
  - Nordicised Mediterraneans
  - Mesocephalic Nordics
  - Others
- Iron Age types
  - A. Keltic
  - B. ?
  - C. Hallstatt
- Minority types

Beaker type. This is defined by the combination of the following features: (a) A brachycephalic or mesocephalic head with a somewhat flattened occiput. This flattening is rarely as pronounced as in the Dinaric type (see later) and the occiput is usually rounded; but it is always steep, high, and broad and the post-auricular segment of the head is short. (b) Great development of the long bones, seen in the extremely long legs and arms, long hands, and, to a lesser extent, in the width of the shoulders. (c) Light pigmentation. The hair is usually light in color. It is often blond, but red hair is very frequent with this type. Eye colour is commonly blue or grey, though darker eyes are sometimes found in association with light hair colour. The skin, in the blondest haired people is sometimes dull white, but characteristically it is very red and is often freckled. (d) A long, broad, squarish face, with prominent cheek bones, and a broad, deep jaw with well defined gonial angles. The face is solid in appearance, but often fairly fleshy, with deep naso-labial furrows.

The head is shorter and broader than the average, and is usually fairly high.

The parietal bones rise steeply, and are practically parallel for a considerable distance. The forehead is broad, slightly rounded and fairly high, with average to strong brow ridges, and little constriction. The eyebrows are usually thin. The nose is generally straight or wavy in profile, though concave noses are not uncommon, and a thickened upturned tip is characteristic. The nostrils are usually wide, and the nasion depression is deep. The hair is often deeply waved. The hand long and narrow, and not fleshy, and the medius is short in relation to the hand.

The body build of this type is best described as athletic.[1] As a rule these individuals are muscular. Their sitting height is about average, but the legs are very long and the stature is generally very tall (average about 5 feet, 10 inches). Weight is moderately heavy (about 11 stone — 154 lbs.). The span is very much longer than the stature, normally 105–6% of the stature, whereas the average for the population as a whole is 102.5%. Shoulder width is medium to broad, and the chest measurements are good. Metrically these chest measurements are only about ahe average for the population, but they are considerably above those of other types, being exceeded only by the Palaeolithic stocks. The width of the hips (bi-iliac width) is fairly large, wider

[1] The body types were generally classified into: hyperlinear, linear, athletic, solid, lateral. Athletic is probably related to the linear constitution Solid was used for fairly small, strongly built individuals. Lateral is wider in hip breadth and has a deeper chest measurement.

than in the Mediterranean groups, but not so broad as the Upper Palaeolithic types.

The type is one of the most easily distinguished in the Irish population, though it forms only about 5% of the total. It would appear to grade into what we believe to be a Borreby Palaeolithic element — a tall brachycephalic which is often red haired, and has great length in arm and leg, and a particularly long face. The Borreby type is distinguished by the following features — a rounder and larger head with flattening in the lambdoid region, relatively larger face and a lateral body build. This "pure" Borreby type forms only about 0.5% of the population.

On the other hand it grades into a form which might best be called a Proto-Nordic, from which it is differentiated mainly by a longer head and a lack of marked occipital flattening. The length of the arm and leg is similar. It is rather difficult to be sure either from statistical work or general observation that this is really a stabilised type — it may represent a mixture between the Beaker and one of the longer-headed elements, but it is quite useful as a classificatory category.

Dinaric types. The classic Dinaric type is found only rarely in the Ulster population, but its distinctive features make it an easily isolated element. It is similar to the Beaker, in having a brachycephalic head with a flattened occiput, but as a rule this is even flatter than in the Beaker type. It is clearly distinguished, however, by the rest of the physical features:

(a) Pigmentation is darker. Often the hair is black or dark brown; the skin pale, or reddish brown (there is generally some suggestion of pigment). The eyes, though characteristically dark, are occasionally light.

(b) The shape of the parietal bones is rather different. In the Beaker type, they are more parallel at first; in the Dinaric, there is greater convergence, and the head height is higher.

(c) Though stature is tall, the legs are relatively short, and the body length is often considerable. The average span is only slightly longer than the stature. The arms and legs are thus very much shorter than in the Beaker type.

(d) The body build is more linear; the chest smaller, both narrower and shallower. Shoulders are generally very broad, but the hips are narrow.

(e) The face is narrower and the cheek bones are less prominent. Though the upper facial height is on the average much the same.

the jaws are shorter, and relatively narrower. The chin is usually well marked; the lips thin.

Two features which make this Dinaric type especially conspicuous are:

1. A long, narrow convex nose, which is very prominent, and has often a thin and depressed tip. The root is narrow and the nasion depression well-marked.

2. Thick concurrent eyebrows. (Concurrent eyebrows are found in Ireland with certain of the Upper Palaeolithic types. But they can be regarded as entirely typical of the Dinaric group, where about two out of every five of the dark-plano-occipitals have this characteristic. It is rare to find this feature with any other racial type.)

The forehead in this type is high and rounded with average brows and fair frontal constriction. The slope is usually strong. The hand is small with short fingers.

A certain number of individuals are found who appear to have some of the characteristics of the typical Beaker and some of the typical Dinaric.[2] An estimate, based on general observation only, suggests that roughly one in ten of the mesocephalic and brachycephalic plano-occipitals shows a mixed form.

The "pure Dinaric" type is rather a small element in the northern population. We estimate it to form about 2% of the total, but in spite of its small numbers it is an extremely conspicuous and well-defined type.

Dinarics — group B — Mediterraneans, partially Dinaricised. We also find a number of individuals with flattening of the occiput who are mainly of Mediterranean affinities. They lack the concurrent eyebrows, hooked nose, peculiar shape of the parietals, and extreme occipital flattening that is characteristic of the true Dinaric. They are generally small, solidly built individuals, with relatively short legs. The head is flattish in the occipital region, and fairly short in length; the face is broad with a fairly shallow jaw. The nose is generally wavy in profile with a full tip. Hair, which is usually deeply waved, is dark; eyes are often light.

[2] It is possible that many of the red-haired Beaker people represent a Dinaric element in which the black pigment has been lost. Convex noses and greater occipital flattening appear to be found more often with the deeper red pigmentation. A lighter sandy colour is more often found with the rounded occipital type. We have not yet sufficient evidence to decide the point.

From the evolutionary point of view it may be that the Beaker type was derived from the Borreby. If this is so, we have, by historical circumstances, both survivals of the original stocks, and later derived forms, which evolved from this type on the continent, present in the same populatoin.

The first main Mediterranean element in the population is the tall Atlanto-Mediterranean type. Its characteristics are:

(a) A dolichocephalic head form with a high vault, and often a projecting occiput. The head is large in size, very long, generally over 200 mm. in length, of moderate breadth, and relatively high.

(b) Tall stature (average about 5 feet, 9 inches): a linear body build with poor chest development, the chest being both narrow and shallow. Sometimes an athletic body form is found, but more often the tendency is towards a hyperlinear form. Weight is medium in relation to the height (c. 10–6 stone — 146 lbs.). The span is generally short compared with the stature. It is often less than the height, but the average is about 101.5% — this is the lowest ratio of any of the physical types in Ireland. The shoulders are broad and straight and the hips narrow.

(c) Pigmentation — the hair is dark, but the eyes are often blue. The skin is rather pale, sometimes reddish-white.

(d) The face is narrow and usually long, and the general relief is bony though the projection of the malars is slight. The forehead is wide, with a fair constriction, and the slope is generally fairly strong. Browridges are well marked, medium to strong in size. Eyebrows are long and often thick. The jaw is deep, the chin well developed. The nose is most frequently straight, but a high proportion of convex noses — usually a smooth and gradual curve — are found. The nasion depression is often slight, and the nasal tip medium to thin. In conformity with the general build the hand is long and thin, with a very long medius.

This tall Atlanto-Mediterranean type grades rather gradually into smaller Mediterranean varieties, and we think it best to define two main groups:

(a) Basic Mediterranean — small, dark, long-headed individuals with narrow faces.

(b) Derived Mediterraneans — often metrically similar to the Basic Mediterranean, but distinguished by certain more "infantile" characters.

Basic Mediterranean. The type is fairly similar to the Atlanto-Mediterranean, and is distinguished mainly by its smaller size. The head form is similarly dolichocephalic with a high vault. The forehead is generally straight in profile with a moderate slope, usually steeper than in the taller Mediterranean variety. There is a good minimum frontal constriction, and browridges are slight to medium. There is usually some projection of the occiput. The face is variable in length, generally long, and is narrow in width. Cheek bones are usually prom-

inent with little flesh covering, but their projection is slight. The nose is almost always straight, rarely convex. It is narrow, and the nasal tip is thin. The nasion depression is average to well-marked.

In body build, they are lightly built individuals, small in stature, with fairly broad shoulders, narrow hips, and small chests. Arms are rather short.

Pigmentation: the hair is dark, and the eyes are probably darker on the average than in the taller Atlanto-Mediterranean variety. The skin is pale, sometimes red-white, occasionally brownish-white.

As a group it corresponds in general with the smaller Mediterranean varieties of Southern Europe, but it is scarcely possible to separate out of it individuals of the taller Atlanto-Mediterranean variety who are lacking in general growth factors.

The Derived Mediterranean group consists of small high-vaulted dolichocephalics who show a combination of various infantile features, e.g., partial depigmentation, shallower chest, slight jaws, wavy or concave noses, rounded foreheads, relatively short legs, "Mongoloid" eye folds, etc. Metrically they are often indistinguishable from the small Mediterranean type, and we regard them not so much as another racial group, as individuals who are affected by this general evolutionary process of foetalization.

In the mesocephalic group it is also possible to extract a type of Mediterranean affinities. They are individuals with a rather indiscriminate head form which is best described as pear-shaped. The head vault is not particularly high, and the profile of the parietal bones, as seen from the back, is a somewhat semicircular form. The forehead is rounded both when seen from the vertical and lateral profiles, and the browridges are slight or absent.

The face is generally short — (but a large proportion appear to have lost their teeth fairly early) — with a straight nose, and a shallow jaw. Hair is usually dark, sometimes dark blond, and eye colour is generally grey or blue. The face is usually smoothly contoured and fleshy.

Generally, body build is poor: stature small, and shoulders rather narrow, chest development slight, and musculature feeble.

Neanthropic — Upper Palaeolithic Derivatives. It is one of the astonishing characteristics of the Irish population as a whole that a large proportion of its genetic make-up is apparently derived from Upper Palaeolithic stocks, and that such a large number of individuals correspond so well with the Upper Palaeolithic types as known from archaeological excavation.

The main distinguishing features of Upper Palaeolithic man, in general, are:

(a) Great body build, with massive bony structure, heavy musculature, and exceptional weight.

The body is usually long relative to the total structure; the chest measurements are particularly great — especially the anterior posterior measurement. The great hip width (bi-iliac breadth) is an outstanding characteristic, and this feature has sufficiently high differential value to enable a high proportion of the Palaeolithic types in a mixed sample to be isolated at once.

(b) The head size is extremely large, generally with strong brow-ridges and flattening in the lambdoid region.

(c) An exceptionally wide face, exceeding all other racial types, often with marked projection of the zygomatic arches. The facial length is variable including both very short and very long forms.

(d) The lower jaw is massive, unusually broad and deep.

It is possible to distinguish several main groups in this population: A. A hyperdolichocephalic element with a very long narrow head. B. A mesocephalic group with a head of very large absolute dimensions. C. Miscellaneous mesocephalic forms. D. Occasional "pure" Borreby survivors. E. Derived forms.

A. In the first main Palaeolithic type, the head is long and narrow and extremely large in size. In relation to the breadth the head vault is low, there is pronounced flattening in the lambdoid region, and the occiput bulges slightly at the back. The temporal regions are steep, and ill-filled. The forehead is broad and slopes back sharply. The eyes are deep-set below strong brow ridges, and the inter-orbital breadth is great.

The facial relief is rugged, with enormous cheek bones and strong lateral projection of the zygomatic arches. The length of the face varies — it is either exceptionally short or extremely long, and the difference between these two types lies mainly in the depth of the jaws. The nose is prominent, usually straight or convex in profile and the tip is often full and thick. There is no noticeable prognathism.

The body build is usually recorded as linear, but the chest and hip measurements are particularly large. The type is tall in stature and very heavy in weight. The body length is long relative to the total height, and the arm length is considerable. They move with a rather slow, loose, awkward gait.

Dark hair and blue or gray eyes is the usual combination of hair and eye colour.

From the metrical data alone we find the contrast between the Palaeolithic and Mediterranean dolichocephalics to lie mainly in the following features:

(a) The height of the head in relation to the breadth — the index is consistently lower in the Palaeolithic types.

(b) The facial width.

(c) The bi-iliac and chest measurements.

B. The mesocephalic Palaeolithic type is probably more common in Ireland as a whole, though in Antrim we found that dolichocephalic types far outnumbered the mesocephalics. Occasionally we find individuals with a cephalic index which, strictly speaking, is dolichocephalic, but whose width is 160 mm. or over. We consider it best to regard these as part of the mesocephalic group.

In these individuals the body is particularly large, with a voluminous chest, and an exceptionally broad bi-iliac width. Stature is usually tall, the span wide, and the weight is extremely heavy. There is a noticeable tendency to put on weight with age.

The head is very large in size, both long and broad and high. Usually the occipital projection is slight, and the occiput is rounded, flattening off in the lambdoid region. The post-auricular region appears short. The forehead is broad, with a moderate slope and average to strong browridges. Eyebrows are often rather thin, but generally long.

The face is very broad and massive in appearance. It is generally long, though short faces are sometimes found. The zygomatic arches do not as a rule appear to project as much as in the dolichocephalic type but the width is still particularly great. The eyes are deep-set, the nose straight with a full and often slightly upturned tip. Concave noses are found, however, more often with the mesocephalic type than with the dolichocephalic. The jaws are deep and massive, and very broad in relation to facial breadth. The general appearance of the face is solid, but the relief is not bony, for there is generally a good covering of flesh, and naso-labial creases are often deeply marked.

In pigmentation the hair is usually brown, the eyes frequently blue, and the skin reddish in exposed parts of the body, but pale where unexposed.

C. Occasional Borreby survivors also turn up, but they probably form only about one-half per cent of the population. They are solidly built brachycephalics with extremely large heads and massive faces.

Body build is solid to lateral, but the arms and legs are usually rather long. Chest measurements, both anterior-posterior and transverse, are exceptionally great.

For a brachycephalic the great head size is exceptional, length alone often exceeding 200 mm. and the breadth is usually over 160 mm. and on occasion may reach 170 mm. In shape it is rather globular, and the post-auricular region is relatively short. The occiput though not high and flat after the Dinaric pattern, usually rises very steeply at first, and flattens off into the parietals. There is therefore definite flattening in the lambdoid region. The forehead is high and broad and usually steep.

The facial region is large relative to the size of the head. Cheek bones are very broad, and the face is somewhat flattish in appearance. In contrast with this massive face, the nose is short, concave, and infantile, with a full upturned tip, and the nasal segment is short compared with the total facial height, the jaws being particularly deep and broad. The face is often fleshy, with heavily marked naso-labial creases, and a large mouth, though the lips are not particularly thick.

The pigmentation is light, fair or red hair, blue or gray eyes, and a reddish skin.

D. We often come across individuals with smaller heads who are of undoubted Palaeolithic affinities. From the measurements of head length, breadth, and height, and facial breadth, these would often fall within the standard of the Mediterranean category, but the configuration of the occipital and parietal bones, together with the facial relief, leaves no doubt as to their ultimate affinities. Usually their lateral body build is sufficient to identify them with the Palaeolithic stock. This is an instance where the conventional quantitative approach does not express form adequately, and may therefore be highly misleading.

E. We are also inclined to the belief that many small-statured small-headed mesocephalics are ultimately of Palaeolithic derivation. We found, for example, that if we took the small-statured mesocephalics, they fell into two groups, and the differences between these groups paralleled exactly the differences between "Mediterranean" and "Palaeolithic" types. It seemed likely therefore that one group of mesocephalics was ultimately related to the Palaeolithic stock. In investigating the mental hospital material, there has not been sufficient evidence to form an opinion on this matter.

Nordics. The "Nordics" present one of the most difficult problems in our classificatory scheme. The concept of Nordic has usually been taken to imply blondism, but in the Irish population blondism alone

cannot be regarded as indicative of "Nordic type." In the first place observation suggests that blond hair is found with individuals of every conceivable physical type, and no one dominant blond type stands out. If we calculate the mean measurements for a group of blonds we do not find that they differ from a random sample of the population as a whole.

In our initial studies therefore we rather ignored hair color as a racial factor and based our classification on metrical and morphological features. It was then discovered that certain racial groups had definite distinguishing features in pigmentation also, and it was possible to examine in rather more detail the differences between blonds and brunets. In finding out what differences were associated with blondism we could use as a reference standard, not the mean for the total population, but the general typological scheme. The view reached was that we certainly could not speak of a stabilized Nordic type. Many of the blonds appeared to belong to otherwise definable types. But there were continuously a number of differences. In certain cases these could best be regarded as the retention of certain infantile features. A number of other factors, however, would appear to be operating. Environmental adaptation may have to be reckoned with, but how or why, or in what degree, it is impossible to say at the moment. We are inclined to the belief that the process of progressive blondism has been accelerated by mixture between certain types — possibly between Mediterranean and Palaeolithic — but new racial forms appear to be rare, and the Nordicized individual shows a tendency to belong predominantly to one or other of the otherwise defined types.

The classification proposed here is based on the supposed origins of the various Nordic elements. As a classificatory scheme it seems to work fairly well in practice.

(a) Blond Atlanto-Mediterraneans. From the metrical and morphological point of view these are often indistinguishable from the typical dark Atlanto-Mediterranean, but as a group they show a greater frequency of concave noses, and the forehead is often rounder and smoother. On the other hand the legs and arms may often be longer.

(b) Nordicized Mediterraneans. This covers all the remaining individuals of Mediterranean stock who have light hair and eyes.

(c) Beaker Proto-Nordic. These are long-legged, long-armed individuals, often with a reddish tinge to their hair, who have a somewhat short post-auricular region of the head, though lacking the brachycephalic form of the true Beaker.

(d) Nordic form Palaeolithic. These individuals often show a great ruggedness of facial feature, malar projection, or configuration of the skull that is typical of the Palaeolithic stocks, but they usually lack either the extremely broad face and projecting zygomatic arches, or else the great chest and bi-iliac width.

(e) Minority types include certain infantile "Nordics" Mesocephalic heads, with rounded bulbous foreheads, short upturned concave noses, round fleshy faces, and short legs. These would often appear to be a foetalized Palaeolithic element.

(f) Tall Mesocephalic Nordics. We occasionally find in the north of Ireland tall fair-haired mesocephalics. They are essentially of Mediterranean affinities, in the sense that they do not show either the lateral body form, ruggedness of cranial features, or configuration of the head that are characteristic of the Palaeolithic stocks.

Their body build is athletic. They are tall, with very broad shoulders, relatively narrow hips, well developed chests, and fairly long legs and arms. Their heads are large (typical measurements $201 \times 157 \times 137$) with broad high foreheads (MF 110). Brow ridges are usually strong. The temporal region is fairly full, the occiput rounded and occasionally flattish. The face is long and broad, usually with measurements around 130×140 — on the average above those of the Atlanto-Mediterraneans and below those of the Palaeolithics. The nose is long, straight or convex in profile, the tip often fairly full, but the nostrils fairly thin. There is some slight lateral prominence of the malars. The lower jaw is generally deep.

The hand is longer and broader than the average, with moderately long fingers.

In pigmentation, the skin is pale or florid, the eyes blue, occasionally grey, and the hair light.

Iron Age Types. The following types are much more easily distinguished by observation than by metrical analysis alone. As far as can be judged from the scanty cranial evidence they are probably types which entered Ireland in the Iron Age.

A. Keltic? This type is distinguished by the following features:

(a) A mesocephalic, sometimes dolichocephalic head, with a rather low head vault. In the mesocephalics, at any rate, the height/breadth index is very low, but in many of the dolichocephalics it would appear to overlap with the range of the Atlanto-Mediterranean group. As seen from the side the profile appears almost semi-circular, and the occiput is rounded. From the back the profile is somewhat cylindrical with a rather constricted occiput. The forehead is wide, curved in profile,

and slopes back strongly. Brow ridges are slight, and frontal constriction is not great.

(b) The face is long and broad, with a long narrow nose, which is narrow in the root, has a prominent bridge (often a hooked nose), and a fine tip. Naso-labial creases are deeply marked. The jaw is generally fairly wide, but smoothly contoured.

(c) The hair is dark or light brown, the eyes blue and the skin pale.

(d) The hair is very fine and exceedingly sparse; one of the commonest features is baldness on the top of the head. (In the Dinarics and Beaker types baldness is rarer and occurs much later in life. In most individuals of Mediterranean type, the hair recedes first from the temples, and only secondary on top.)

(e) Body build is linear, and they are particularly light-boned people of fine musculature. Though stature is average to tall, weight is unusually light. The shoulders are broad, the hips narrow, chest about average, and arms long.

(f) The hand is apparently rather broad and fairly fleshy, and the bi-styloid wrist measurement appears to be great.

B. The following type is one which would seem to be found very frequently among the working class urban population, but so far very few individuals have been measured. The description has been based mainly on observation.

The head is medium in size and mesocephalic. The occiput is generally rounded, the forehead slope is moderate, its profile straight, and browridges slight to average. Eyebrows are long but sparse. The chief characteristic is the general prominence of the nose, which is large, usually strongly convex in profile, and spreads out widely into the face. The face itself is both long and broad, though the depth of the jaws is apparently not great. The general relief is coarse and bony.

Body build is usually solid and thickset — going from fairly linear forms to athletic, but both the hyperlinear forms of the Atlanto-Mediterranean and the extreme lateral of certain Palaeolithic forms are absent. Stature is small, with a fairly long body. The shoulders are not very broad.

The hand is slightly broader than the average, but is of medium length. It is fairly fleshy and the wrist is relatively thick.

Pigmentation. The eyes are almost always light, either gray or blue.

Hair. Colour is rather more variable but tends towards the lighter shades. The observation of this feature is complicated by the fact that greyness in the hair appears to come on fairly early. Skin colour is reddish white or pale.

C. There also appears to be a small group in which the head profile, as seen from the side, is somewhat like a parallelogram. A high, strongly sloping forehead, gradual sloping backwards of the parietal bones, and a jutting occipital. This occipital form differs from the curved, low-down projection of the Atlanto-Mediterraneans. The face is prominent, with strong malars, and the nose is long and strongly convex.

We have, however, insufficient data regarding this type.

In addition to these main elements certain minority types are occasionally found.

(a) Tall brachycephalics with very dark pigmentation. They are broad-shouldered men and solid in build. They differ from the Dinarics in having a rounded and not a flattened occiput.

(b) A sub-variety of the dolichocephalic Mediterranean described below (Corded type?):

This variety is rather rare; but the same combination of differences from the typical Atlanto-Mediterranean form appears to recur in sufficient numbers in different areas to make it a definite subgroup.

The cephalic index is hyperdolichocephalic (about 73) and the height/breadth index is particularly high. The parietal bones are steep, and the forehead high, broad, and flattish. The face is long and narrow, but the nasal segment is rather short, and the jaw is deep. The zygomatic arches are rather constricted and the jaw is generally narrow. The nose is usually straight or slightly convex. The occiput is flattish as seen from the lateral profile; it rises steeply, but is not broad (and has a marked median ridge?) The hand is often fairly short, and the medius too is slightly shorter than the average.

The stature appears to be fairly tall; and the body length relatively great. Shoulder width is average, the hips are narrow, and the chest is medium in width. The span is usually less than the stature.

CORRELATIONS BETWEEN RACIAL TYPES AND TYPES OF PSYCHOTIC REACTION

The first stage of the investigation was the measurement of a sample of patients at Purdysburn Villa Colony, Belfast. A sample of 103 individuals was obtained and a limited number of measurements were taken on several additional individuals (e.g. patients in bed).

Twenty-seven measurements were taken on each individual, and a number of observational details recorded.

The patients selected were mainly schizophrenics or manic-depressives. Mental defectives (oligophrenia), epileptics, seniles, GPI's were excluded. Any whose physical measurements were noticeably affected by old age, and any not derived from Ulster stock were subsequently omitted. But several of Scottish descent were retained, as they did not differ from normal Irish types.

The mean measurements for the sample are given in table 2. They are all noticeably smaller than the means for county Antrim as typified for example in the Ballymoney sample. The explanation for this appears to lie both in the racial composition of the sample and in the socio-economic status of the subjects measured. There is not sufficient evidence to imply general biological inferiority. The sample is mainly from the city of Belfast and the general social status, revealed by the occupations (table 3), fairly low. The largest category is general labourer. We have no data relating to the city population, but a group of miscellaneous unemployed — mainly from urban areas shows even poorer physical measurements (Walmsley, Mogey and Gamble, '42). We think the figures for the hospital sample would be about the average for the urban working class population.

In its racial composition it shows some divergencies from the rural population. For example the tall, large-bodied Paleolithic type which forms such a high percentage (up to 20%) of the rural samples, is found only rarely in the city population. Less than 5% of the Purdysburn sample showed any affinities with the Palaeolithic stock — and 2% at least were not natives of the city. As the men of this type were deliberately sought out from a larger number, the real proportion is certainly less — probably ½%. Nor are the other tall or strongly built types much in evidence. The tall Atlanto-Mediterranean group appears to be much rarer than in County Antrim, and the dominant elements are the smaller-statured Mediterranean and Iron Age types. As will be seen in table 1 the means for the whole sample bear quite a close resemblance to those of the small Mediterranean type as found in the Ballymoney area. In short it is considered that the differences between the means for this sample and the samples from County Antrim could easily be accounted for by differences in the racial composition of the samples and by environmental conditions.

The sample of just over 100 men, from such a heterogeneous population as that of Belfast was considered too small for a detailed statistical analysis. It was seen that certain racial types would be repre-

sented by only one or two individuals. We therefore relied on the general classification that had been worked out, and grouped each individual according to this scheme. At the same time this gave an excellent opportunity for trying out certain general ideas of classification, and enabled us to acquire further descriptive data regarding certain of the types.

TABLE 2

Mean measurements.

MEASUREMENT	ABBREVIATION	PURDYSBURN		BALLYMONEY	
		Mean	No.	Mean of total	Mean of Gp II
Stature	ST	1672	103	1720	1670
Span	Sp	1709	101	1770	1670
Sitting height	SH	877	103	910	900
Weight	WT	..	..	..	9½ st.
Bi-acromion width	BA	383	102	388	370
Bi-iliac	BI	286	103	305	290
Chest transverse	T	273	103	290	283
anterior posterior	AP	216	103	224	215
circumference	CC	830	103	910	870
Head circumference	Hcc	556	101	..	..
length	L	193.0	103	197.4	194
breadth	B	149.1	103	152.7	149
height	H	136.6	103	136.8	136
minimum frontal	MF	107.9	102	107.0	104
Face bi-zygomatic	BZ	135.8	103	140.3	135
nasion mention	NM	125.3	103	124.1	123
upper facial height	UFH	74.6	103	..	..
Nose length	NL	58.3	103	54.4	54
breadth	NB	35.3	103	35.0	33.5
Bigonial width	BG	104.3	103	106.1	104
Hand length	HL2	190.3 *	103	HL190	188
breadth	HB2	86.1 *	103	HB 89.4	87
medius	LM2	109.2 *	103	..	..
bi-styloid	BS	59.1	103	..	..
wrist circumference	Wcc	169.2	103	..	..
max. hand circumference	MHcc	230.6	103	..	..
cicum. at knuckles	Kcc	208	101	..	..
Cephalic index	C. I.	77.3	103	77.2	76.7
H/B 100	..	91.7	103	89.6	91.2
H/L 100	..	70.9	103	..	..
MF/B. 100	..	72.3	102	..	..
NM/BZ 100	..	92.3	103	..	..
NL/NB 100	..	60.8	103	..	..
BI/BA	..	74.7	102	..	..
AP/T	..	79.3	103	..	..
NL/NM	..	46.5	103	..	..
T.I. SH/St	..	52.5	102	..	..

*. Difference in technique between this and Mr. Mogey's work.

After the preliminary analysis of the Purdysburn sample certain general ideas suggested themselves, and racial types which were represented by only one or two individuals were sought out in other mental hospitals and the type of psychoses recorded. Here it was not considered worth spending time on measuring, as further measurement added nothing to our knowledge of the types. It was found to be perfectly satisfactory to record descriptive data — about thirty observations on each man. This had the advantage of taking much less time, and with certain types of restless patients was easier than measurement. It served well to establish an individual's "racial identity."

First an attempt was made to correlate individual measurements and indices with the types of psychotic disorder.

TABLE 3

Table of occupations of patients examined: Purdysburn

	NO.
Labourer	37
Trades — joiners, glaziers, painters, carpenters, etc.	7
Transport — motor drivers, vanmen	4
Soldiers, sailors	8
Technicians, factory hands	10
Clerks	9
Distribution — shop assistants, message boys	6
Miscellaneous	16
Unemployed and unrecorded	9
	106

In most physical features the correlations were absent or so low as to be unsatisfactory. In the body measurements there were only one of two exceptions:

(a) Span. Those individuals with wide spans showed a tendency for the manic-depressive reaction group. 14/20 with spans over 1780 mm. were of this group, and there were only four schizophrenics.

(b) Bi-iliac width. Slight correlation between broad hips and manic-depressive reactions. Of those with widths of over 306 mm. ten were depressives and five schizos.

In weight, however, a most noticeable correlation was found. Of those under 8 stone, 5 lbs (117 lbs.), twenty-eight were of the schizoid and paranoid groups and only nine depressives. The average stature for these depressives was somewhat smaller than that of the schizoids, so that the weight was relatively more.

In the group over 10 stone (140 lbs.) only one schizophrenic was found, though there were nine depressives and several confusional and paraphrenia. In the next weight group 9.4 to 10 stone (126–140

lbs.) the depressives just outnumber the schizophrenics, 10 to 7, but the average stature of the schizoids is above that of the depressives ($1\frac{1}{2}$ cm. taller). It would seem as if weight in relation to body size was highly correlated with the type of psychoses. Unfortunately, there is no really satisfactory formula for epressing the body/weight relationship. Formulae taking into account stature alone e. g. $\frac{Wt}{St}$ are extremely treacherous, for different racial types have different types of body form, e. g. two types of identical stature may have great differences in the leg length/body length ratio. The only solution would be to measure the total body volume in a graduated bath and use this together with sitting height/stature and chest anterior-posterior/transverse indices. As weight would appear to be a partial function of race, occupation, age, health, nutrition, time of year, etc., it was decided that from the existing data it would be very difficult to pursue the study of the correlation between weight and psychoses any further. The group was then analysed into its racial elements. This was straightforward and 86% were eventually classified.

The Mediterranean element. The Mediterranean element was the dominant group in the sample. The tall Atlanto-Mediterraneans were few in number, but were entirely typical. The smaller dark variety was the most numerous, and a number of an infantile mesocephalic category were also found. A high proportion of the blonds (Nordics) were also to be regarded as of Mediterranean affinities.

The Mediterranean group as a whole showed a great predominance of schizophrenic reaction types (table 4); especially so, if one took only the most typical individuals. The proportions were:

depressive	16.4%
confusional	7.3%
paraphrenia	3.6%
schizophrenia	72.8%

On a pure chance distribution one would have obtained about equal numbers of depressives and schizophrenics. The depressives were then examined in detail to see if there were any features in which they differed noticeably from the rest. The first obvious point was a difference in age (table 5) — the average for the nine depressives was 44, whereas the average age of the schizophrenic group was katatonia — 28 and simple type — 25. The age at which confusional states occurred was also later than the true schizophrenia, and younger than the depressives. The age at which the depressive reaction occurs tends to be rather later than in the other racial groups (except the Palaeolithic) characterized by effective psychoses. A second noticeable point

was that whereas a relatively shallow chest is characteristic of the Mediterranean group as a whole, and especially of the schizoid group, the depressives very frequently had a chest with an extremely high AP/T index. The average index is about 75, but in this group of nine depressives it is 91 — the depth being almost as great as the width.

TABLE 4

Relationship of psychotic and racial types.

	MEDITERRANEAN																PALAE-OLITHIC		
	Atlanto Mediterranean	Small do.	Basic do.	Mesocephalic	Mixed Mediterranean	Nordics Gp. f.	Nordics Gp. a and b.	Iron Age Gp. B	Dinaric	Iron Age — C	Nordic Corded	Beaker	Nordics fr Beaker	Nordics Gp. D	Nordics Gp. E	Iron Age — A. Kelt	Dolicho.	Mesocephalic	Derived
Manic depressive																			
Involutional melancholia																		1	
Depression	1	.	3	1	2	1	1	3	2	.	1	1	4	3	1	1	.	1	3
Elation	.	.	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	.	.	.
Alternation	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.
Confusional	2	.	1	.	1	.	.	.	.	.			.						
Paraphrenia	.	.	.	.	.	.	2	.	.	.			.						
Paranoia	.	.	.	.	.	.	.	3	.	.			.						
Schizophrenia																			
Paranoid	.	.	.	.	.	.	.	3	.	.			1						
Katatonia	4	.	6	2	1	1	3	.	.	.									
Hebephrenia	1	.	1	.	.	.	.	1	.	.									
Simple	2	2	6	6	2	.	3	1	.	1							1	.	.

* Mixed medit. — Dinaricised.

There are possibly tendencies of differentiation within the Mediterranean group as a whole. The somewhat infantile mesocephalic type usually tends towards the simple type of dementia praecox, whereas the more masculine Atlanto-Mediterranean tends towards katatonia. The age at which the small mesocephalic Mediteraneans were admitted also tends to be younger than in the other groups, 23 compared with 27–28 for the rest.

The group labelled Iron Age Nordic — group B, in spite of its smaller numbers offered some extremely interesting contrasts with the main Mediterranean element.

In the first place, the age of admission was definitely later — average 39. Secondly, the number of paranoids found was very high. Only eight paranoids were recorded in the whole sample of 103, and six of

TABLE 5

Age and psychoses.

	MEDITERRANEAN RACIAL GROUP					
	Atlanto	Basic	Mixed	Mesocephalic	Nordic Gp. a & b	Total
Depressive	36 (1)	46 (3)	47 (2)	41 (1)	43 (2)	44 (9)
Confusional	34 (2)	42 (1)	45 (1)			39 (4)
Paraphrenia	..	..	..	..	34 (2)	34 (2)
Schizophrenia						
katatonia	26 (4)	29 (6)	28 (1)	22 (2)	29 (4)	28 (17)
hebephrenia	25 (1)	30 (1)	..	..	..	27 (2)
simple	29 (2)	27 (6)	21 (2)	24 (6)	26 (3)	25 (21)
	26 (2)					
Occupation						
subordinate	24 (2)	25 (7)	..	22 (6)	30 (3)	25 (18)
technical and independent	28 (5)	31 (5)	..	28 (2)	28 (3)	28 (15)

AVERAGE AGE OF SCHIZOPHRENICS
MEDITERRANEAN RACIAL GROUP

	No.	Age
Nordics	7	28
Basic	13	28
Atlanto	7	27
Small Atlanto	2	26
Mesocephalic	8	24

DEPRESSIVES

Group	No.	Age
Mediterranean	9	44
Dinaric	2	35
Beaker	2	34
Nordics		
From Beaker	4	39
From Palaeol.	3	37
Corded	2	34
Palaeolithic	5	53

them turn up in this group of eleven individuals. In addition one of the remaining individuals — classed as depressive, showed originally definite paranoid trends. The later average age of admission of this group does not appear to depend entirely on the fact that paranoia is a disorder which comes on later in life. The age at which the few cases of schizophrenia occur are also very late.

		age	
e.g.,	hebephrenia	27 (1)	
	d.p. simple	34 (1)	
	schizo. paranoid	33 (3)	
	paranoia	51 (2)	(plus one age unrecorded)
	depression	39 (3)	

The Nordic elements appeared to have the characteristics of the groups from which they were derived. Those mainly of Mediterranean affinities are characterized by schizophrenic reaction types, those of Palaeolithic and Beaker derivation by depression. In these individuals, however, the average age at which depression occurs is very much earlier than in the depressives of Mediterranean stock. It is possible that paraphrenia occurs rather more frequently with Nordic types than with the "pure" Mediterranean, but the evidence is not really sufficient to enable us to decide the point.

With regard to the characters of the Beaker racial type it is difficult to associate them with any one standard psychotic reaction type. Manic-depressive types, occasionally depression alone, appear to be most frequent. On the other hand, it is easy to give a general characterization which holds good for most of this type. It is essentially little control over their emotional and physical urges. There is quick and violent emotional release. They are apt to be "touchy" in temperament, often aggressively impulsive, sometimes violent without realizing their own strength — instincts of self preservation are dominant, and not under control.

Only one individual of undoubted Iron Age group A (Keltic?) was observed in Purdysburn, together with one who was possibly of this type. He was one of the few cases of the elated phase of manic-depressive reaction type. The doubtful individual was a depressive type. But a number of individuals of this racial type were observed in Antrim and Downpatrick. They were all amazingly active individuals, it being usually difficult to keep them still long enough for even observational details to be recorded. They were all extremely talkative, with a continuous flow of language, and generally noisy, often abusive, and sometimes with paranoid attitudes. All the normal individuals of this racial type known to the author, show great "social activity" both in general quickness of body movement, talkativeness, and eagerness. It is a type that finds itself on numerous committees, and delights in organizing. They only become socially dangerous either when a paranoid attitude is associated with such general activity, or when the general control over the activity becomes lost, and the motor activity controls the man.

These are the only two types in which noisiness and violence seem indicated as a general characteristic, and it is unfortunate that at the moment we have so little information about the distributions of these racial types. If we had maps showing the frequency of these types and the relative frequency of these types of psychotic reaction, it would be

easy to see whether any fundamental correlation is found. (Both types we should expect to increase in numbers as one goes south in Ireland, though in the western peninsulas they would not be particularly numerous.)

Palaeolithic types. Of the few individuals of this stock in Purdysburn depression was the main characteristic. The age of onset is fairly late. Even with material from other hospitals it was difficult to associate them with any specific psychosis. A dull apathetic attitude was common, but delusions and hallucinations are sometimes found. A certain number of cases of mental defect were observed but it is doubtful whether this occurs with greater frequency than in the Mediterranean group. Typical schizophrenic reactions are apparently not found, and there is none of the activity of the Beaker and Keltic types.

As far as one can judge the mental characters of this type from knowledge of the normal population, one could say that they were very slow and cautious, generally pleasant, and mild tempered, but may become talkative when once started. On the average, general intelligence is probably not as high as in the Mediterranean group. General reactions of body and mind are slow.

The Dinaric racial type is probably of mixed origins. It is fundamentally of Mediterranean affinities altered by other factors. Coon believes this to be admixture with Alpine racial stock. If schizophrenia is associated with the Mediterraneans in general and depressive reactions with the Alpine brachycephalics one should expect symptoms of both schizophrenia and manic-depressive groups. The two examples noted in Purdysburn were of depressive reaction types. On further enquiries one was found to have certain paranoid trends. In the Downpatrick and Antrim hospitals, men of this type were classed as paranoid and katatonic varieties. Hebephrenia, and simple dementia praecox were not found in any of the men of this type. One other important point may be noted. Epileptics were not examined, but it was realized afterwards that in noting Dinaric types, a very high percentage of epileptics were picked out. Looking back it would certainly seem that the number of Dinarics who were epileptics was out of all proportion to the size of the Dinaric group as a whole. From memory alone, I should say that about one in four of the Dinaric type encountered were epileptics.

A further characteristic noted amongst the Dinaric type in general is that a large number of them are exceptionally good technicians. It cuts across socio-economic boundaries, from dentists to fitters, weavers and electricians. And if in Ireland one connected them with the

early Bronze Age metal workers one would not, I think, be far wrong. If technical ability is found so frequently with this group, occupational therapy might prove of more than average value to men of this racial group.[3]

CONCLUSIONS, REFLECTIONS, AND SUGGESTIONS

The general conclusion reached from this survey is that definite correlations between mental and physical characters seem indicated. The high correlations between certain types of psychoses and certain racial types together with the factors of age, and development, suggest that the constitutional aspect is of prime importance. At the same time neither psychiatry on the one hand, nor anthropology on the other, has progressed sufficiently to prove satisfactory conditions for the study of the correlations. We think, however, that if we can succeed in classifying a sample into racial types differences in temperament will be found between these groups. If the typology is not clear cut, then the mental characters appear also to be mixed.[4]

Looking back on this first excursion into the field, one feels that rather too much has been based on too little data. At the same time, it has fulfilled its avowed object — a general survey of the field — and should provide a useful starting point for any future work. Given time and opportunity it should be fairly easy to obtain more precise data relating to the problem, and results of supreme importance might be achieved.

For a satisfactory investigation, I consider that at least 1000 patients would need to be examined. (I am thinking in terms of Ireland only, where we have the necessary background — knowledge of the normal population, both the data collected by Mr. Mogey, and by the Harvard expedition, whose results are still unpublished). A minimum of fifty for each racial type would certainly be required. A detailed case study would have to be made for each patient, and the symptoms of abnormality reclassified statistically.

[3] This view as to the Dinarics being good technicians relates only to Ireland. It is not meant as characterizing the European Dinarics as a whole. Nor is it really a "scientific" statement of fact, but it is hoped that other investigators will watch out for this point and produce evidence for or against it.

[4] Summarizing our own opinion about the classification. we regard the following types as well established and defined:

Beaker; pure Dinaric; Atlanto and basic Mediterranean; Palaeolithic-dolichocephalic; mesocephalic large-headed type and Borreby. Iron Age A is fairly definite, but it is difficult to say at present when it runs into the Neolithic Mediterranean gruops. With regard to the rest, we require still further data and confirmation. The classification of the Nordics is making the best of a difficult situation. From the studies completed since this scheme was first worked out it seems quite satisfactory.

In brief, for any one who combines the training of an archaeologist, anatomist, statistician, psychiatrist, sociologist, and has the capacities of a calculating machine, an extremely attractive field lies open.

ACKNOWLEDGMENTS

Special thanks are due to Professor Walmsley (Dept. of Anatomy, Queen's University, Belfast) for the loan of anthropometric instruments. I am under a deep obligation to the Superintendent and Staff of Purdysburn Villa Colony for the generous assistance they gave me. To Dr. C. B. Robinson, I owe an especial debt of gratitude for his helpfulness.

I am grateful also to the Superintendents of Downpatrick and Antrim Mental Hospitals for the opportunities they gave of visiting their hospitals.

I wish also to acknowledge my indebtedness to Mr. John M. Mogey M. A., whose anthropometric survey in Co. Antrim and Co. Derry provided metrical data without which this study would have been impossible.

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REVIEWS

THE STONE AGE OF MOUNT CARMEL. THE FOSSIL HUMAN REMAINS FROM THE LEVALLOISO-MOUSTERIAN. Volume II. By THEODORE D. McCOWN AND SIR ARTHUR KEITH. Oxford Univ. Press, Oxford. xxiv + 390 pp., 88 tables, 247 figures, 28 plates. 1939. ($20.00).

The fossil human skulls and skeletons found in cave burial-places on the western slope of Mount Carmel form the subject of this study. They come from the Levalloiso-Mousterian layers of Mugharet et-Tabūn (Layers C, B) and of Mugharet-es-Skhūl (Layer B). The artifacts and fossil faunas of the strata in which the human remains were imbedded have been described in volume I, The Stone Age of Mount Carmel (D. A. E. Garrod and D. M. A. Bate, Oxford, '37).

The skeletal material gathered from Mugharet-es-Skhūl represents ten individuals: Skhūl I, a male infant about 4–4½ years of age; Skhūl II, a female 30–40 years old; Skhūl III, an adult male; Skhūl IV, a male, 40–50 years of age; Skhūl V, a male about 30–40 years old; Skhūl VI, a male, 30–35 years of age; Skhūl VII, a female, 35–40 years old; Skhūl VIII, a male child, between 8 and 10 years of age; Skhūl IX, a male 50 years of age; Skhūl X, a male infant about 5–5½ years of age. The material gathered from Mugharet et-Tabūn consists of the bones of two individuals; Tabūn I, a female about 30 years old and Tabūn II, a male, 30–35 years of age. In none of the cases are the skeletons or the skulls complete, and some individuals are represented by only a few bones. Skhūl III, for instance, is only known by parts of the left leg and Tabūn II only by an isolated mandible. All of the skulls have been crushed. Skhūl IV and V are the most complete; then follows Tabūn I. The rest of the skulls are very defective.

The Skhūl individuals were associated with a characteristic Levalloiso Mousterian industry; the two Tabūn individuals with an archaeological layer which yielded implements of a type almost indistinguishable from those of the Skhūl stratum. In the fauna, however, there is a sharp change — not between the layers of Skhūl, on the one hand, and Tabūn, on the other but between the Layers C and B of Tabūn itself. The proportion of the animal forms has altered. The most abundant bones in Layer C are those of wild oxen while gazelles dominate Layer B. Layer B also lacks certain species which are characteristic of Layer C. But the human individuals, Tabūn I and II belong to Layer C, and the fauna of this layer et-Tabūn is the same as that of Skhūl. From the anthropological viewpoint it is important that the human population was not affected by these changes. The Tabūn man and woman were contemporaneous with the Skhūl population and both lived before the time of the faunistic change. Only isolated teeth and fragments of a maxilla with some teeth belong to the later period of Tabūn (Layer B).

Each separate bone of the skeletons found both in Skhūl and Tabūn deposits has been thoroughly described, measured, illustrated by drawings or photographs and compared with suitable representatives of Neanderthal and modern man. A great work worthy of admiration and imitation has been produced, and one which is of lasting value because of its documentary character. Furthermore, it should

be an extremely valuable work of reference particularly for its anatomical descriptions of bones heretofore unavailable or inadequately described.

Although the existing differences between the individual specimens are not unimportant, nevertheless in so brief a review as this it is impossible to refer to each of them. Twenty-five diagnostic characters are established by the authors and these are as follows:

Men tall (1700–1787 mm.). Women, short (1537–1580 mm.). Head strongly dolichocephalic or mesocephalic (index 68.0–77.0). Vault of medium or above medium height (length-auricular height index 54.4–63.0). Calotte-height-index 41.0–60.9. Well-developed supraorbitals but with a tendency to separate into a medial and a lateral portion. Forehead moderately full (frontal angle 62°–90°). Occiput slightly projecting. Face of moderate length, usually orthognathous (facial angle 73.5°–97°). Malar bone flat and anthropoid-like. Maxillae devoid of canine fossae, usually without a snout. Orbits wide but not high (width 42–46 mm., height 30–37 mm.). Nose variable in projection and width (index 52.8–58.6). Subnasal area wide but not deep. Mandible variable: some small, some large; some robust, some weak. Chin absent or moderately developed. Mandibular ramus wide or moderately wide; mandibular angle moderately developed. Teeth large or moderate in size; molars with certain primitive characters. Spine showing certain Neanderthaloid features and others like those in modern man. Adaptation to bipedal progression as perfect as in modern man. Lower limbs long. Cranial capacity ranging from 1271 cc. (Tabūn woman) to 1587 cc. (Skhūl man). Brain showing no decided difference in size or form from that of modern man.

In a second, more specific list, embracing all characters of the whole skeleton, the authors arrive at the conclusion that the Mount Carmel man has 16 (14.4%) characters in common with Neanderthal man and 32 (28.8%) in common with modern man (Cro Magnon man). Forty-six characters or 41.4% are intermediate between Neanderthal and Cro-Magnon man. Thirteen (11.7%) of the characters are indeterminable and 4 (3.6%) are peculiar to the type. The Mount Carmel people, the authors conclude, are much more akin to the Cro Magnons than to the Neanderthal people of western Europe. As to the relationship of the Mount Carmel population with the paleolithic peoples outside Europe — with the exception of those represented by the Galilee skull — the authors take this position: "their relationship to the prehistoric peoples of the East is distant both in space and time".

In one respect it is very difficult to follow the authors' ideas. They stress the fact that the Mount Carmel population consists of two types. One is represented by the female skull (I) of the Tabūn deposit, the other by the male skull (V) of the Skhūl deposit. The former represents a typical Neanderthalian with low cranium, receeding forehead and chinless mandible. The second belongs to a peculiar type — so far unknown — with high cranium like the Galilee skull, vertical forehead and very pronounced supraorbitals but with a well-developed chin like that of modern man. Yet in their analysis of the Mount Carmel population and its comparison with other paleolithic types the authors treat this population as a unit although the Tabūn I type may have had other relations than the Skhūl V type. The authors' statement that the Krapina as well as the Ehringsdorf people find their closest resemblances with the Neanderthal peoples of western Europe and not with the Palestinians can only be maintained by neglect

of the Tabūn-type. For the same reason they are not justified in stating that "the Neanderthal of Europe is not found among the Mount Carmel people" but at the same time to claim that "the Krapina type, the Steinheim Skull and the Ehringsdorf group approach very closely to the Tabūn woman". The so-called "Neanderthalians" of Europe are no more a unit, morphologically speaking, than the Mount Carmel population. On the other hand, the only representatives of modern mankind with whom the Palestinians have been compared are the Cro Magnon and the Predmost people. The Cro Magnon is put forward as a "European, Caucasian or white". The modern-man-type which "makes its appearance amongst the Skhūl people" is regarded, according to the authors, as "a very particular form of modern man" but "one of the white or European type". On such a basis McCown and Keith finally arrive at the conclusion that the Mount Carmel people are not the actual ancestors of the Cro Magnons but "Neanderthaloid collaterals or cousins which must have evolved somewhere in western Asia."

In this reviewer's opinion, the essential fact which came to light in the discovery of the Mount Carmel population and in their excellent description by McCown and Keith is that we are confronted — for the first time — with a population which consists of both "Neanderthal" types, such as the Tabūn woman, and several, morphologically more advanced types. The Skhūl V man who is considered characteristic of the Skhūl population is not yet modern man although he has already developed a high cranium, an erect forehead and a chin. Yet he still has pronounced supraorbitals although they are on their way to disintegration like those of typical Neanderthalians. The Skhūl V man is, therefore, a transitional form between the Neanderthal types and modern man, the latter being represented rather by Skhūl IV and IX with supraorbitals much less developed than in Skhūl V.

The explanation given by McCown and Keith for the contemporaneous occurrence of Neanderthal type (Tabūn I woman) and of forms intermediate between this and modern man is a very complicated one and one which may be best understood with reference to Sir Arthur Keith's previous attitude on the question of Neanderthal man. The occurrence is not "due to miscegenation" but to "an evolutionary *divergence*" (italics mine), the authors assert, as the Mount Carmel population were presumably "in the throes of an evolutionary change". If the latter assumption is accepted, the best interpretation would seem to be that Skhūl V, morphologically ranging between Neanderthal and modern man, is a new type, and evolved from the Tabūn I type, advancing, therefore, in the direction of modern man. Whether this evolutionary movement is in the direction of Cro Magnon man or any other form of the Upper Paleolithic European or North African does not matter much.

Unfortunately, the authors do not make their precise position explicit. Long before the Mount Carmel population was discovered, Sir Arthur Keith always clung to the idea that Neanderthal man formed a mere side branch of the main human stock and represented a blind end in human evolution. He believed that modern man took origin from an ancestor (so far completely unknown) who united an anthropoid mandible with a human brain case — like the "Eoanthropus" chimaera. It would seem, therefore, that Sir Arthur Keith's present

views are not consistent with those he formerly advanced. The "evolutionary divergence" mentioned earlier means that, before the Mount Carmel time, there was a common stock "the individuals of which were undergoing differentiations along, at the least, two directions — toward the pure Neanderthal type and toward recent-man type represented by the early people of Cro Magnon". The Mount Carmel people show "divergence" into these two types.

As the authors claim that these people are "in the throes of an evolutionary change", they seem to believe this tendency to diverge was not finished but was still going on. What has happened to the two diverging forms, the Neanderthal type of Tabūn and the intermediate type of Skhūl is not indicated. Has the former died out? And into which form of modern man has the latter been transformed if a direct change into the Cro Magnon man is not acceptable? The authors do not dwell on these details. They leave it to the reader to be satisfied with their story.

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CHIMPANZEES: A LABORATORY COLONY. By ROBERT M. YERKES. Yale University Press, New Haven, xv + 321 pp., 1943. ($5.00).

Following his retirement as Director of the Yale Laboratories of Primate Biology, Professor Yerkes has written a fascinating book entitled "Chimpanzees". This book describes the living, acting chimpanzee as revealed by Yerkes, his students, and associates. The writer calls it a "composite portrait of chimpanzee personality done in terms of behavior". The vividness and clarity of the description would make this book enjoyable to anyone interested in animals, even if the subjects were not as inherently fascinating as the livliest of the great apes.

"Chimpanzees" is divided in three main parts. Part one is a general description of social behavior and life cycles. Part two deals with mentality and the experimental procedures used to reveal the mental world of the chimpanzee. Part three is devoted to the problems of housing, feeding, and care.

There is a selected bibliography for those who wish to pursue any particular topic. Sixty-three plates, many of which are composed of three or four pictures, illustrate every phase of the account from cages to parturition. Photographs, supplemented by diagrams, are of great aid in understanding the psychological experiments.

The epilogue, "The Story of an Idea", will be of particular interest to the anthropologist. This part might well be read directly after the prologue. Yerkes points out that his purpose was to develop laboratory animals useful in problem solution. This practical point of view permeates every part of this book. The reader will get an insight into the problems and methods of a branch of experimental science which will be even more valuable to many than the account of the latest "servant of science", the chimpanzee.

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CHILD DEVELOPMENT; PHYSICAL AND PSYCHOLOGICAL GROWTH THROUGH THE SCHOOL YEARS. By MARIAN E. BRECKENRIDGE AND E. LEE VINCENT. W. B. Saunders Co., Philadelphia. ix + 592 pp., 37 figs., 1943. ($3.25).

The amount of information about child development has increased tremendously during the past few years. Consequently a volume of this type ". . . designed for professional students in psychology, teacher training, home economics, medicine, nursing, and social work as well as parents", is a welcome and highly useful addition to the literature of the field.

The organization of the book is excellent. The writing, with occasional exceptions, is lucid; understandable to the intelligent layman as well as to those with professional training. The documentation is extensive and pertinent, and the addition of a bibliography of 806 judiciously selected titles provides adequate opportunity for the reader to examine in more detail special subjects which are of particular interest to him. The work is up-to-date as well as comprehensive — a feature in itself of sufficient importance to warrant its recommendation.

Some errors in fact are apparent. The reviewer's opinions do not coincide in all points with those presented by the authors or some of the cited authorities. To call attention to these errors and opinion differences in a review is unduly to magnify their importance and consequence. To avoid error completely or to fail to attain some opinion difference is an impossible task in a work of this size. The authors exhibit a sound scholarship and a freedom from bias which markedly supersedes their occasional departures into speculative and wishful thinking realms.

Several important contributions of Physical Anthropology to understanding of child growth are discussed. Many suggestions, implicit and explicit, are given which merit the attention of professional workers in physical anthropology and human biology. Certainly the volume is a useful addition to the library of any individual who, either professionally or parentally, is concerned with understanding children. The reviewer recommends it without further qualification.

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AN APPRAISAL OF CONSTITUTIONAL TYPOLOGIES. By WILLIAM ARMAND LESSA. Am. Anthrop., vol. 45, no. 4, Pt. 2, 1943. (No. 62 in the Memoirs of the American Anthropological Association).

In this monograph Lessa attempts to point out the many obstacles "which balk the achievement of more convincing success in this newly emergent discipline." He states that workers in the field of human constitution have directed most of their efforts to the study of morphology and that they have tried vainly to show relationships between body build and such imponderables as temperament, personality, intelligence, criminality and the like. He feels that they have failed "to take full recognition of the obscuring factors of the socio-economic environment." One of his conclusions is that the fault lies not so much with the students of

human constitution and their inadequate techniques, but that most of the blame rests on the shoulders of psychologists, psychiatrists, medical men and others, who have not supplied adequate correlations. He suggests that, "when the other sciences have set their own houses in order, then they will be able to turn over to constitutionalists material which is suitable for research along the lines of biotypology."

Now it is interesting to note that most of the so-called constitutionalists are themselves psychologists, psychiatrists, medical men and others who have come to the conclusion that their disciplines are in need of revision and who have therefore turned to the study of the whole man for a solution to their problems. The point is not so much that constitutionalists must wait until other disciplines are set in order, but that the investigators in these other fields are turning to the constitutional point of view to aid them in doing just that.

In a discussion of criminality as one of the "inadequate" phenomena which have been linked to morphology Lessa berates the positivist school, represented by Lombroso, Goring and Hooton, for claiming that criminals as a group exhibit certain morphological characters which differentiate them from the non-criminal population. After firmly convincing himself that morphological criteria cannot be relied upon to explain the biological character of criminality he suggest that, "Constitutionalists might do well to abandon further research. The results will always be negative." He further states that, "Since crime is a breach of social convention, criminal motivation must be studied from the sociological and psychological approaches."

In this discussion of criminality it is unfortunate that Lessa has elected to give a biased critique of the various criminal studies by pointing out only their weaknesses. The reader of his monograph is left with a distorted idea of the value of the work done in this field. Lessa presents only one side of the picture. He has nothing to say about the many important contributions these studies have made. Unfortunately, he seems to have become impatient with constitutionalists because they have not yet evolved techniques which are able to prove once and for all that there is something to the theory that a criminal's constitutional make-up (which inevitably includes physique) is in part responsible for his mode of behavior. Granted that morphological studies are not entirely convincing, the work already accomplished by and large does show certain trends in the direction of correlations between the physique and temperament of the criminal. If everyone were convinced that criminality has been adequately explained by the sociologists then, of course, there would be no need to delve further into the possible constitional bases for this phenomenon.

In the section on bodily disease Lessa makes some rather dogmatic statements apparently without foundation. For example, he says, "An important consideration which researchers have shunned is this: Under what category of disease is a given subject to be placed? The pratice has been to draw patients from hospital wards and clinics, classifying them only on the basis of current illness." In reply to this accusation it must be stated that such is not the procedure at most of the centers where clinical studies are being conducted. In studying any particular disease group it is obviously of the utmost importance to eliminate from the series any cases which are not clear-cut diagnoses or are complicated by a history of other diseases.

Lessa indicates a lack of knowledge of constitutional medicine when he states, for example, that, "a person with a history of cholelithiasis should, by all the rules of biotypology, never develop gastric ulcers." What are these rules and who made them? We are well aware of the fact that numerous individuals are capable of producing double lesions, i.e., gall bladder disease and peptic ulcer. These are exceedingly interesting cases and are studied as a separate group.

There is more than a suggestion in this monograph that Lessa has not steeped himself in the literature of constitution before attempting to appraise it. It is obvious that he has not read deeply into the original works of consitutionalists, but has preferred in many instances to give a rehash of other people's criticisms. In his extensive bibliography there are many glaring omissions of original contributions in the field of human constitution. The implication of these omissions is that here is one reason for Lessa's insinuations that constitutionalists have not proved much. Although this monograph is on Constitution, Lessa does not mention many of the important studies.

Lessa also attempts to show that there are no acceptable methods for appraising such phenomena as temperament, intelligence, and functional disorders of the mind and that, therefore, it is a hopeless task to try to find correlations between these phases of the total personality and body build for which again there appear to be no adequate descriptive techniques. The picture as painted by Lessa is indeed a pessimistic one. Such would not be the case, however, if he had been willing to point out the many noteworthy contributions and advances which have been made in this field rather than to fill his monograph with insinuations that what has been done has been either futile or done very badly. The fact remains that the mass of evidence already accumulated clearly supports the theory of the unity of the organism. Even greater progress will be made when all investigators in this and other fields accept the proposition that there is no dichotomy of mind and body and that in order to understand individual variations it is necessary to study the whole man.

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FINGER PRINTS, PALMS AND SOLES: AN INTRODUCTION TO DERMATOGLYPHICS. By Harold Cummins and Charles Midlo. The Blakiston Co., Phila., xi + 309 pp., 1943. ($4.00).

The character and contents of this book may best be indicated by quotations from the preface: — "There is a prevalent but mistaken notion that dermatoglyphics have no importance beyond their use in personal identification. Perhaps because the publications of research are scattered and the generalizations hidden in complexities of descriptive methods, it is not generally appreciated that the patternings of epidermal ridges on fingers, palms, toes and soles have broader and more fundamental significance. The configurations are formed in the early fetus and they persist unchanged. Their variants exhibit differential trends among races, between the sexes and among constitutional types. . . . For those of a biological turn — especially anatomists, physical anthropologists, physicians

interested in constitution, geneticists and zoologists — the book is intended as a means of acquaintance with a relatively neglected aspect of human biology.''

This reviewer has long contended that dermatoglyphics is definitely a branch of physical anthropology and should be sedulously cultivated by anthropologists instead of being generally overlooked by them. Hitherto there has been no single publication adequately serving as an introduction to the somewhat complex but not too difficult techniques of dermatoglyphics. This book is likely to become a standard working manual for students of the subject everywhere. If all of us who are engaged in dermatoglyphic research were to follow the standards and methods set forth in this volume, we would understand one anothers' publications more easily than we do at present. There is no better standard to follow, for the authors have had a long and extensive experience in the field and are in a better position than any others that we know of to set standards.

The book is arranged in three parts, each of which is accompanied by an extensive bibliography, which should be valuable as a guide to both old and new students of dermatoglyphics. Part I supplies historical background and general orientation in the field. Part II deals with methods of printing, description of types of ridge patterns and configurations and methods of formulating these. Part III is devoted to the more fundamental biological phases of the subject and is the part that especially needs to be summarized in a review such as this. Of peculiar interest to anthropologists are Chapters 9, 12, 15 and 16.

Chapter 9 deals with comparative dermatoglyphics and shows how this study affords additional means of estimating the affinities of the various Primate groups. This estimate closely follows the orthodox phylogenetic tree. Thus, assuming that prominent, circumscribed volar pads with associated whorl and whorl-like patterns constitute a primitive condition, and lowered and less discrete pads and less complex patterns (loops, arches, open fields) are more specialized, the following seems to be true: Four genera of prosimia (Nycticebus, Galago, Lemur, Tarsius) show diversified pattern development, with Tarsius considerably specialized and hence off the main line of Primate evolution. The New World monkeys are again diverse with the following trend toward specialization: Oedipomodas, Callithrix; Saimiri, Abus; Lagothrix, Alouatta; Ateles. The Old World monkeys (Papio, Pithecus, Cercocebus, Lasiopyga, Erythiocebus) show the least specialization and, in size and form of ridge patterns, are exaggeratedly primitive. Man exhibits more primitive patterns than any of the great apes, with Orang, Gorilla, Chimpanzee and Gibbon showing more specialized patterns in the order named.

In man, it is interesting to note that, generally speaking, finger pattern intensity (high intensity, primitive; low intensity, specialized) decreases from north to south in Africa, Asia and the Americas, but from south to north in Europe. The yellow-brown peoples include those with the most primitive configurations, while Bushmen, Hottentots, Efé (African pygmies) and the Nordic Whites are the most specialized in this respect. Other Negroid and White groups stand intermediate in degree of pattern intensity. Interestingly enough, the Ainu closely resemble the White group in this regard.

Chapter 11 deals with symmetry and other aspects of special morphology and should be read by students of bilateral asymmetry, reversed asymmetry and mirror imaging. Chapter 12 discusses the genetics of ridge patterns and configurations and shows that this field has a real place in the rapidly growing subject

of human genetics. Chapter 13 deals with the use of dermatoglyphics in twin diagnosis. While acknowledging the great value of such materials when used in conjunction with other data, the authors are somewhat sceptical of the validity of dermatoglyphics as a sole criterion in twin diagnosis.

Chapter 15 is concerned with racial variation in dermatoglyphics. As in many other traits used as racial criteria, there appears to be greater intraracial than interracial variability. The real differences between races with respect to such characters are purely statistical and to be explained on the basis of differences in different races in varying concentrations of the genes of several patterns and configurations present in all races.

Chapter 16 deals with constitution and its relation to dermatoglyphics. Constitutional trends are revealed by statistical analysis. Thus, there are significant correlations between pattern intensity and cephalic index, nose form, blood groups; and there are marked sexual differences. There is considerable difference statistically between right handers and left handers. Races differ markedly in arch-whorl indices. Some pathological conditions seem to be correlated with pattern intensities; others do not. Schizophrenics seem to have a lower pattern intensity than controls in the general population; epileptics show a similar trend; while mongoloid idiots show the most pronounced reduction. There are no significant dermatoglyphic trends among feeble minded, imbeciles and idiots.

For those interested in personal identification Chapter 8 will be found highly instructive. Chapter 10 on the embryology of human volar pads, and Chapter 14 on the use of dermatoglyphics in cases of questioned paternity, represent interesting side lines of this large field.

For any student of human biology desirous of adding to his repertoir a new and fascinating research technique the book is highly recommended as a teacher of technique, method of formulation and statistical analysis. The book-making and typography seem to be flawless and the figures are of high quality and practically all original. The book should serve to put dermatoglyphics on the scientific map.

H. H. Newman

RACE AND CRIME. By William Adriaan Bonger. Translated from the Dutch by Margaret Mathews Hordyk. Columbia University Press, New York, xi + 130 pp., 1943. ($1.50).

This slender volume is a translation of the last work of Prof. Adriaan Bonger, who was accounted one of the foremost Dutch criminologists. Nearly half of it is devoted to an elementary summary of various opinions as to the significance and definition of race and to a historical review of what criminologists have said about the relation of crime to race. The author appraises this latter very low grade material with clarity and reasonableness. The rest of the treatise is given over to "case studies." The only data presented that can be regarded as racial comparisons of criminality are a few tables extracted from the United States Census and the Uniform Crime Reports of the Bureau of Federal Investigation. These compare Negroes and Whites. For the rest, there is an interesting dis-

cussion of Jewish criminality in several European countries (valid in this connection only if the Jews are admitted to be a "race"). Finally, on the exceedingly dubious assumption that this or that of Ripley's European races is predominant in a specific country of Europe, the statistics of criminality in that country are offered in evidence as bearing upon the relation of race to crime. The results are negligible, as is inevitable from the quality of the data.

If one adheres to a strictly anthropological definition of race, there is no way of studying its relationship to criminality except an anthropometric survey of criminals. This reviewer, as a result of a considerable experience in this kind of work, is of the opinion that economic status, social environment, ethnic tradition, and individual constitution are severally more important as etiological factors in criminality than race, anthropologically determined. Nationality and national origins, with their implications of social tradition and specific racial blends, are criminologically far more meaningful than physical combinations in the individual whereby a racial diagnosis can be made. Professor Bonger seems to have had a sound point of view and he reached the only conclusion possible from his materials — namely that they prove nothing.

E. A. Hooton
Harvard University

NOTES

SUPPLEMENT TO THE JOURNAL

Various members of the Association have suggested that such subjects as fossil man and constitution be summarized in the Journal. Articles of this type obviously would be useful to the specialist and particularly to all those teaching physical anthropology. However, the Journal is primarily a medium for the publication of original research. Therefore, it has been suggested that there be a yearly supplement devoted to such summaries. It is hoped that this supplement can be added as soon as restrictions due to the war are removed.

EDITOR

ANOTHER PROPOSED CHANGE IN THE BY-LAWS

Article VI, section 2, in the by-laws of the American Association of Physical Anthropologists, states the requirements for Life Membership. No proposal for changing this section was included among those listed in n. s. vol. 1 (pp. 221–224). However, owing to the fact that subscription to the Journal was added recently to the annual dues, the cost of Life Membership is now unreasonably low. The Executive Committee suggests, therefore, that at the next annual meeting the Association vote to decide whether the privilege of Life Membership shall be withdrawn.

S. L. WASHBURN, Secretary.

INTERNATIONAL INSTITUTE FOR AFROAMERICAN STUDIES

In response to the unanimous desire of the First Interamerican Demographic Congress favoring the scientific study of Negro populations in America, a group of delegates and investigators formed, on October 20, 1943, the International Institute of Afroamerican Studies with headquarters in Mexico City (Moneda 13). Officers are:

Dr. Fernando Ortiz, Director
Dr. Gonzalo Aguirre Beltrán, Sub-Director
Dr. Jacques Roumain, Secretary
Dr. Daniel F. Rubín de la Borbolla, Treasurer
Dr. Jorge A. Vivó, Director of Publications

The Institute proposes to study Negro populations of America in their biological and cultural aspects and their influences on the remaining American peoples. The Institute's functions can be summarized in two points:

1. Investigate all aspects of the Negro population of America, not only that of the past but that of the present;

2. Inform the governments, and public as well as private institutions on these matters whenever such information is requested.

The Institute intends to publish an Afroamerican study magazine as one of its principle tasks and will make every possible effort to put out other publications in the future.

Annual membership dues are $2 for individuals and $5 for institutions.

CRANIAL CAPACITY: COMPARATIVE DATA ON THE TECHNIQUES OF MACDONELL AND BREITINGER

M. L. TILDESLEY AND N. DATTA-MAJUMDER
England

The century which has elapsed since the first attempts were made to measure cranial capacity has seen numerous trial solutions of the technical problems involved and the growth of a considerable literature on this topic: for accounts of these the reader may be referred to two of the most recent papers, by T. D. Stewart ('34) and Emil Breitinger ('36). Our own contribution to the subject is to consider carefully the techninque described in the last-named paper and, as far as the data permit, to compare it from the point of view of accuracy with the technique elaborated by W. R. Macdonell ('04) and used by all subsequent workers in the biometric school of Karl Pearson. In respect of speed Breitinger's technique which measures skull capacity in 5 minutes has a very obvious advantage over Macdonell's which takes 20 to 30. Yet if its speed involves a loss of accurary one may hesitate to adopt it in preference; for accuracy of direct measurement affects all figures regarding capacity, not only those for series whose capacities are measured direct, but also for those whose mean capacity is estimated indirectly from their cranial diameters or arcs, the regression formulae on which such estimates are based being derived from cranial series — where possible, kindred series — whose capacities have been determined by direct measurement. But those of us who have had the wearisome experience of measuring a considerable series by the lengthier method of Macdonell can hardly help feeling a hopeful interest in the possibility of cutting down time without cutting down truth.

Breitinger's technique, published in 1936, was first tested partially by Stewart ('37), whose results were not unfavourable; they could not be conclusive, however, owing to differences in apparatus, and to the shortness of the series measured.

The position was next considered by the Conference on the Technique of Physical Anthropology, called together by the C. S. T. A. (Comité de Standardisation de la Technique anthropologique) at Copenhagen in 1938. Section II of its Minutes, reported in MAN ('39, no. 68), contains the following item:

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Cranial capacity, direct measurement: The method recommended by Dr. Breitinger was explained by Miss Tildesley. After consideration and discussion, the conference decided that it would be necessary to submit the matter to a series of further tests, to establish the degree of accuracy to be expected from it in the hands of different observers.

There being no doubt whatever of the wisdom of the above decision — not only in regard to cranial capacity, but to techniques of measurement in general — the authors of the present paper set themselves to test further the Breitinger technique, and to compare the results with those recorded for Macdonell's. We will first consider the latter.

(a) Observational variability in using Macdonell's technique. We owe to W. Hambly ('40) the most direct estimate of an observer's variability in measuring cranial capacity by Macdonell's technique. He measured for a second time, after 6 months, the capacity of fifty skulls from New Guinea, publishing both sets of measurements. Subtracting second observations from first, we get 10.59 cc. as the estimated σ of differences between pairs of measurements by this observer, and $\pm$ 1.06 cc. as its s.e. Assuming the degree of observational variability to be the same on both occasions, we get 7.49 $\pm$ 0.75 cc. as the σ which measures this variability; and this, in terms of the mean capacity of the series (1257.36 cc.) amounts to 5.96 per 1000 cc.

Next we have the evidence obtained by G. von Bonin ('34) who measured series of Whitechapel skulls previously measured by Macdonell. The estimated σ of the M-B differences is 15.48 $\pm$ 1.85 cc., and if we assume the two observers' techniques to be equally variable, the σ of their observational errors is estimated at 10.94 $\pm$ 1.31 cc., or 7.48 per 1000 cc. of capacity.

Von Bonin ('34) also remeasured fifty-eight Farringdon St. crania measured by B. Hooke ('26). The σ of the H-B differences is estimated at 14.05 $\pm$ 1.30 cc. which, on a similar assumption of equality, would give each an observational error whose σ was 6.69 per 1000 cc. of skull capacity.

The only other available data on the observational variability of the individual observer is given by the measurements recorded for test skulls. Table 1 gives nine such sets of measurements, varying in number from 3 to 17. In no case is the series long enough to give a reliable estimate of σ by itself; but, expressed in terms of their respective means the fifty-six measurements (with forty-seven degrees of freedom) might perhaps be combined together. The question is whether, when thus expressed, they can be considered as random samples from the same "population" of observations, whose σ they would then estimate as

5.09 per 1000 cc. To answer this question, we apply Bartlett's μ-test, and this shows that there is only about one chance in twenty-five of obtaining, from the same population, nine samples of the given sizes differing as much in variability as these. The chance is not so small as to be ruled out for that reason alone; but on general grounds it seems unlikely that the five observers to whom we owe the nine sets of data would tend to repeat, with equal degrees of consistency, the movements they made, though the differences may not have been great.

To sum up our evidence; — apart from the "composite" estimate of 5 cc. per 1000, which cannot be given any exact interpretation, we have, from three other series of data, estimates of the σ of observational variability in applying Macdonell's technique, which range from 6 to 7.5 per 1000 and average 6.7.

(b) Differences of bias in applying Macdonell's technique. Initially, there should be no difference of bias between different observers' measurements, because all who follow Macdonell's directions obtain their own personal equations between the weight of tightly packed seed they get into test skulls and the water-capacity of the latter, and thereafter they calculate skull-capacity from seed-weight by means of these equations. For subsequent measurements to be free from bias, however, three conditions must be fulfilled: (1) the mean weight of seed the observers would pack into a test skull must have been ascertained without more than a negligible standard error; (2) water-capacity must have been accurately determined; (3) the personal equation found from the tests must remain unchanged.

In the two instances in which the results of measurement of the same skull series by two observers is recorded, it is evident that all three conditions could not have been fulfilled by both of the pair, for their means differ significantly. Von Bonin's remeasurement ('34) of the thirty-five Whitechapel skulls obtained 1451.6 cc. as their mean capacity, as against 1472.1 cc. found by Macdonell ('04), the estimated difference in bias between the two observers being thus M-B = (20.5 ± 2.616) cc. Von Bonin's measurement of fifty-eight of the Farringdon St. series, previously measured by Hooke ('26), showed a difference in the other direction; von Bonin's mean being 1494.4 cc. and Hooke's 1483.8 cc.: — difference of bias estimated at H-B = (− 10.5 ± 1.83) cc. Presumably, therefore, Macdonell and Hooke had a difference of bias which, if both has measured a cranial series whose mean capacity was of the order of 1450–1500 cc., would have produced a pair of means differing by 30 cc. or so, i.e. about 20 per 1000 cc.

TABLE 1

Data on variation in weight of seed packed into test skulls on different occasions by observers using Macdonell's technique.

OBSERVER	SKULL	GM. OF SEED	MEAN	SUM OF SQQ. OF REDUCED DEVNS.[1]	DEGREES OF FREEDOM	ESTIMATE OF VARIANCE
Macdonell ('04)	α	1130.58				
		1123.70				
		1127.21	1127.16	18.6310	2	9.316
Macdonell ('04)	γ	1364.97				
		1381.31				
		1365.47	1370.58	91.9439	2	45.972
Macdonell ('04)	δ	1052.07				
		1058.83				
		1048.44				
		1061.43	1055.19	96.5246	3	32.175
Tildesley ('21)	δ	1071.00				
		1062.55				
		1063.50				
		1064.30				
		1060.30	1064.33	57.0139	4	14.253
Morant ('23)	T27	1332.2				
		1345.4				
		1349.9				
		1351.6				
		1353.8				
		1350.3				
		1357.2	1348.63	216.5159	6	36.086
Morant ('23)	δ	1062.2				
		1060.2				
		1056.9				
		1061.7				
		1058.7	1059.94	16.9554	4	4.239
Hooke ('26)	γ	1376.0				
		1378.5				
		1379.5				
		1380.0				
		1379.0	1378.60	5.1051	4	1.276
Von Bonin ('34)	δ	1069.2				
		1070.7				
		1078.0				
		1074.7				
		1067.7				
		1070.2				
		1068.5				
		1072.1				
		1060.7				
		1072.8				
		1063.0				
		1061.8				
		1076.5				
		1058.5				
		1075.5				
		1055.0				
		1062.2	1068.06	645.7451	16	40.359
Von Bonin ('34)	δ	1063.1				
		1062.0				
		1071.3				
		1067.5				
		1064.5				
		1062.0				
		1061.9	1064.61	67.3878	6	11.231
			Totals	1215.8235	47	
"Combined" estimate of $\sigma = 5.086$ per 1000 cc.						

[1] The "reduced deviations" are deviations from the mean, divided by the mean and multiplied by 1000.

It may be added that between Macdonell's measurements and the subsequent ones here recorded the capacities of test-skulls δ and γ were modified by repairs, and the seed had doubtless shrunk somewhat in the interval of 17 years or more since Macdonell used it. Differences in the mean weight of seed packed into the same skulls by him and by later observers must not be taken as evidence of differences of bias.

As to the reasons for these discrepancies, we can now see in the light of our data on observational variability, that (for one thing) too few measurements of the test-skulls were taken by Macdonell and by Hooke (see table 1) to satisfy the first of the conditions mentioned above. If we take the σ of an observer's variability in filling a test skull to be, say, 6.7 cc. per 1000; and if, for determining the mean weight of seed he would pack therein, we set as our standard of exactness a 95% chance of being in error by no more (when weight is translated into volume) than 2.5 cc. per 1000: — 3.5 cc. in a skull of 1400 cc.; then twenty-eight fillings are required. If we are satisfied with a 95% chance of being within 5 cc. of the correct mean for a skull of this size, it is enough to measure the skull fourteen times. As table 1 shows, however, we, whose data it records, have been content, with the exception of von Bonin, with considerably fewer test measurements to determine our personal equations.

The second condition of accuracy, in measuring personal equation, is that the water-capacity of the test skull (or skulls) shall be ascertained correctly, and as anyone knows, who has tried it, this is not easy. The irregular surface of the interior of the skull-base offers excellent harbour for air-pockets, when water is poured into the inverted cranium; and though discreet and repeated tiltings will allow most of it to escape (and one hopes all of it), there is no practicable means of verifying this hope. Again, the foramen magnum could never be regarded as an ideal spout from which to pour the water from the skull into the measuring-cylinder; one has to use some other vessel as intermediary; and though no water may then be spilt, some will adhere to the surface of the vessel, and to the inner and outer surfaces of the skull. The latter difficulty is avoided by Mollison's ('32) method of calculating water-volume from the weight of the skull empty and full, but (to be accurate) it needs a balance which is able to take as heavy a weight as the filled skull, and at the same time to record it to a fine unit. This combination of qualities is not common in balances, and, in any case, this method was not used by any of the biometric school with whose data we are now dealing. Furthermore it is not always a simple matter to waterproof a skull satisfactorily, though here again the Munich school seems to have found good methods, which will be given in section (f) of this paper.

We have only a few data on the effect of the various obstacles to exactness in measuring water-capacity, for though doubtless all of us repeated the measurement more than once, only Macdonell ('04) and Morant ('23) give details. Macdonell obtained from duplicate measure-

ment of the test skulls α, γ and δ the following water-capacities: — α 1445 and 1465 cc.; γ 1790 and 1790 cc.; δ 1375 and 1385 cc. The capacity with which, in each case, he compared the weight of seed, in order to determine his personal equation, was the mean of the two measurements; his reason being that "an air-bubble may have formed in the recesses of the skull in the first experiment, or a slight leak may have developed in the second, or I may have made some mistake in filling, or in noting, the volume of water." But since all sources of error mentioned by him or by ourselves, except mistakes in "noting the volume of water," would reduce water-capacity below its true value, Morant's procedure would seem to be the better one: having obtained from three measurements of water-capacity 1350, 1360 and 1365 cc. respectively Morant adopted the highest of these values as the most correct.

The third condition for avoiding bias is that, when once personal equation has been determined, it shall remain unchanged. Hambly's data ('40) demonstrate no change in his, during the 6-months' interval between his two measurements of the fifty New Guinea skulls there is a difference of 1.32 cc. between the two means, but the estimated σ of his observational differences in measuring this series being 10.59 the s. e. of this difference would be ± 1.50 cc., making it quite non-significant. The only other relevant record we can quote is from Morant ('23) when at the outset of his craniometric career he began the standardization of his own density of packing. The series he was studying was the Tibetan, and after some preliminary practice, he first filled a single skull, T 27, seven times with the results quoted in our table 1. He then filled each skull in the series, recording the weight of seed packed into each. "After an interval of a week, this operation was repeated and a fairly uniform increase in weight on the first readings was found though it never exceeded 15 gm." He made sure of a stabilized personal equation during the second series of measurements, by finding the weight of seed held by the test skull δ once on every day over which the work extended.

To sum up, we have seen that the bias, which Macdonell's technique was designed to avoid, has not always been avoided; but having analyzed its causes we have seen how differences of bias could be reduced to a very small amount.

(c) Breitinger's technique. Breitinger's study of the problem, made at the suggestion of his chief, Theodor Mollison, in order to carry further the contribution made by the latter in 1932, begins by an examination of the properties of rape-seed and mustard-seed. Rape-seed had been used until then by the Munich school, mustard-seed by the Bio

metric school of Karl Pearson and most American schools. Breitinger's decision in favour of mustard-seed was a welcome contribution to the international standardization of anthropological technique.

He then approached the problem of capacity-measurement through a careful study of the behaviour and density of the seed, in skull and in measuring cylinder, as affected by various controllable factors such as rate and direction of flow, height from which it falls, amount of shaking, prodding and pressing, dimensions of funnel and cylinder. In thus studying seed he had the advantage of a glass skull, similar to the bronze one prepared by Ranke. Maximum density was not aimed at, and experiment was needed to find a procedure which would make seed density in skull and cylinder equally great. Since seed poured into a cylinder settles itself somewhat more densely at the lower levels, to which it has fallen from a greater height, and since average density is thus slightly diminished as the quantity poured in is increased, the filling in large skulls had to be slightly less dense than in small, to correspond.

The apparatus used by him is as follows:

i. A funnel, equilateral in section, diameter at top 18 cm., diameter of spout 15 mm., height of spout 10 mm., say (this dimension being unimportant). A line 2 cm. wide is painted round the inside of the funnel 5 cm. above the spout; a metal ring is soldered on to the outside of the funnel where it rests on the cylinder, to ensure that it is erect and the spout central to the cylinder.

ii. A cylinder whose inner dimensions are 50 cm. in height by 73 mm. in diameter. The one used by Breitinger is figured by Mollison ('32) and is of brass 2 mm. thick, with a broader base which raises its overall height to 51.5 cm. A second brass cylinder, fitting closely into the first and furnished with a lid, serves the double purpose of containing the seed when not in use, and measuring the quantity of seed in the larger cylinder. It is graduated on the outside to show, at 10 cc. intervals from 0 to 2000 cc., the amount of space between its own base, resting on the seed, and the bottom of the cylinder in which the seed is being measured, the upper rim of the latter coinciding with 0 of the graduation, when no seed is there. To facilitate the reading of seed-volume, at one place the upper rim is bevelled down and is plated with German silver.

iii. A pot [1] for pouring seed into the skull; a short stick 20 mm. in diameter and rounded at the end; a chaff-cushion on which to bed the skull; and "best quality mustard seed", a hundred of which, when arranged in a straight line and touching, he found to measure on an average of 217 mm.

[1] In Mollison's description of the apparatus it says "Topf mit Ausguss" — pot with spout — though not whether it is an open spout as in a jug, or closed.

The following is a translation of the summary he gives of the procedure finally adopted, the few further details (which are given in the body of his paper) being inserted in parentheses:

i. Bed the skull on the chaff-cushion, forehead obliquely downwards.[2]
ii. Pour the mustard seed in through the funnel; the seed should be kept piled up in the funnel to a third of the way up ("until it becomes stationary"); by tilting the skull gently on the cushion, the seed still in the funnel empties itself completely into the skull.
iii. Shake the skull with the hands laid on flat, forehead obliquely downwards ("upper arms pressed to the sides of the body, wrists slightly stiffened").
Rate: four to-and-fro movements ("four single movements") per second.[3]
Time: (a) 15 seconds with the hands on frontal and occiput, (b) 15 seconds with the hands on the sides of the skull.
iv. Pour in more seed slowly out of the pot; at the same time with the left hand tilt the skull, resting on the cushion, in all directions.
v. Distribute the seed by probing six times with the wooden stick, viz. to the right slanting forwards, sideways, and backwards, and the same to the left. ("The wooden stick meets, without going deep into the seed, with that resistance which it is its object to test rather than to bring about").[4]
vi. Fill up again slowly from the pot while tilting the skull on the cushion.
vii. Make a final distribution of the seed by means of the thumb; ("the thumb, resting on the seed, does not sink, but only needs to regulate the last distribution of the seed"; and again "after filling up again — after shaking — one presses the contents more closely together, first with a wooden stick and finally with the thumb"); then fill up the skull to the rim of the foramen magnum.
viii. ("The seed is poured all at once into the funnel; . . . it is absolutely necessary to see that its spout is held in a central and erect position in the cylinder; . . . the funnel described regulates quite easily and automatically the filling of the cylinder"). Insert (inner) cylinder gently (ruhig).
Observational errors varying with the time of day, or other period of time, can be reduced to a minimum if the test-skull is measured again after every ten measurements of other skulls.
After being used for some time the mustard seed should be freed from accumulated dust by means of a sieve.

[2] The angle at which the forehead is inclined to the cushion would be limited by the necessity of inserting the spout of the funnel into the foramen magnum and keeping the funnel upright.

[3] If one counts aloud when shaking, one for each double movement (thus counting up to 30 in 15 seconds), the rate of counting is as much as one can manage comfortably, in English, when numbers over 20 are reached. The exact rate must of course be obtained, at first, from a stop-watch.

[4] The insertion of the stick, however, certainly presses the seeds more closely together, as is stated in par. iv; and one can do nothing, as the result of the "test", except perhaps empty the skull and begin again.

Though the above detailed directions do much to standardize the technique of those who wish to do exactly as Breitinger did, one finds, when applying them, that there are still some points which leave room for individual differences of procedure: (1) The thickness of the stream of seed, which is poured in direct from the pot into the skull, is not specified, except that it should be poured in "more slowly" than through the funnel-spout, the interior diameter of the latter being 15 mm. Yet, as Breitinger points out, the rate, at which seed is poured in, affects its density in the skull: the more slowly, the more dense.[5] (2) The amount of tilt in different directions, during the second and third fillings, may vary from observer to observer, also the rate at which the skull is tilted round full circle,[6] and consequently the extent to which the seed is dispersed by this tilting. (3) Instructions as to the use of the thumb are open to interpretations that vary somewhat in respect of the amount of pressure used, and the direction in which it is exerted. These various ambiguities, however, permit the observer to modify his procedure experimentally, until the interpretations adopted give a mean result which agrees with the capacity of the test-skulls as measured by water.

(d) Results of Breitinger's tests of his technique. First as to the degree of variability in Breitinger's own application of his technique;—The data he furnishes consist of the range, and of σ as he calculates it, which would be by the cruder method, given in Martin's Lehrbuch and generally followed by the German school. We therefore have to apply Sheppard's correction to Breitinger's σ^2 to get the variance of his samples and then multiply it by $\frac{n}{n-1}$ to get the estimate of his variance in measuring skulls of the size in question. As to Sheppard's correction, we see from Breitinger's records of range that he measured weight to the nearest gm. and volume to the nearest cc., and in both cases therefore the amount to be deducted would be 0.0833. Multiplying by $\frac{n}{n-1}$ brings us, when his n is largest, to an estimate of variance whose square root (σ) is the same as Breitinger's value, but with the smaller n's to a value somewhat higher. In dealing with his data we shall use only the estimates of σ derived as above, and s.e.s based on these.

We take first the figures showing his variability in filling the skull with seed. A test-skull whose water-capacity was 1340 cc. was filled fifty-three times: mean weight of seed 1027 gm., σ estimated at 2.02 gm. Translated into volume the estimated σ becomes 2.64 cc., or 1.97 cc. per 1000.

[5] One way to regulate the stream of seed from the pot would be to use a teapot or similar vessel with a closed spout, the spout being of a given size at its narrowest; and one advantage of a curved teapot spout would be that the seed could be poured in vertically. Poured in from a jug held in the right hand, it runs to the left.

[6] If Breitinger did thus rotate it: he only says "tilt in all directions".

Besides weighing the seed Breitinger also measured its volume in the cylinder in the manner described above, and any variability in the latter process should be reflected in the σ of volume thus determined, which should show an increase. The σ obtained however is less than before, being only 1.72 cc. Referring the ratio $\frac{2.64^2}{1.72^2} = 2.356$ to table 5 of Fisher and Yates ('38) we find that a ratio as large, or larger, has rather less than a 1 percent chance of occurring at random. When however we look for an alternative explanation of a reduction in variability we fail to find it, for the only systematic factor affecting the cylinder readings of seed-volume is the slight decrease in density with increased amount of seed. Within a range of only 10 cc. this is practically nil and, if it were not, would exaggerate rather than underestimate the variability in quantity of seed. It would seem therefore either that the smaller figure obtained is due to one chance in a hundred, or else to a slip in arithmetic such as occurs unfortunately more frequently than that. In any case, since variations in the process of cylinder-filling would increase seed-variation as measured by volume, the figures furnish no evidence of variation of the process as carried out by Breitinger, and indeed his apparatus, and his directions if carried out exactly, standardize this process pretty completely.

We may therefore take his further data on variability in volume (measured in cylinder) of seed used in repeated fillings of a single skull, as a correct measure of variability in quantity of seed. These further data give the results of filling thirty-one times a test-skull whose water-capacity was 1701 cc., and provide a σ estimated at 4.035 cc., or 2.37 cc. per 1000. This is not significantly different from the 1.97 cc. found from the smaller skull.

We next come to the question of parallel decrease of seed-density in skull and in cylinder as the size of skull increases. Data for the cylinder were obtained by measuring the volume of 10 weighed quantities of seed rising from 200 gm. to 1500 gm., the last seven of which give the following densities which we can compare with the mean seed-density in filling the two test-skulls:

Vol. in cylinder	1040 cc.	1304 cc.	1439 cc.	1575 cc.	1711 cc.	1848 cc.	1986 cc.
Density in cylinder[7]	.769	.767	.764	.762	.760	.758	.755
Water vol. of skull			1340 cc.		1701 cc.		
Mean density in skull[7]			.766 ± .0002		.758 ± .0003		

From these figures, in the skull of 1340 cc., seed-density would be the same as in the cylinder; in the skull of 1701 cc. slightly less, to an extent that would result in skull-capacity being overestimated by 5 cc.

[7] Breitinger's figures, of which we give the reciprocals, give the number of cc. per gram.

The discrepancy is small, but that shown by the figure he gives us, for mean volume of seed used, is still less (1701.2 cc. ± 0.725). Whichever is the truer measure, we can accept his conclusion that the technique can be applied to skulls of widely different sizes with a high degree of accuracy.

His remaining data are from the measurement twice over of ten small Melanesian and ten large Bavarian skulls: differences between the means were respectively 0.2 cc. and 1 cc., the values of σ agreeing to the nearest cc. in both cases. Obviously by a slip, he has given his σ for the two series of skulls as 15.5 and 14.8 cc. instead of 155 and 148 cc. He adds that "the results obtained by other observers for comparison agree satisfactorily with these," and we could wish he had recorded them, for it is precisely the need of such comparative figures, that prompted our own enquiry into this technique.

(e) Tests by Tildesley and Datta-Majumder of Breitinger's technique. Two test-skulls, a small one painted red and a large one blue, were filled by each of us thirty times on two occasions, except that on the first Tildesley filled only the red one, and on the second there were only twenty-two fillings by Datta-Majumder of the blue skull, the estimate of variability derived therefrom being accordingly not very reliable: —

		ESTIMATED σ OF REPEATED FILLINGS OF	
		Red skull	Blue skull
Feb. '42	M.L.T.	(30) 5.62 cc. per 1000	
	N.D.M.	(30) 3.26 cc. per 1000	(30) 4.47 cc. per 1000
Mar. '42	M.L.T.	(30) 3.15 cc. per 1000	(30) 5.26 cc. per 1000
	N.D.M.	(30) 2.90 cc. per 1000	(22) (2.70 cc. per 1000)

Comparison of these figures with those found for Breitinger's variability in skull-filling (1.97 cc. per 1000 for the smaller of his skulls, 1.37 for the larger) suggests that he is the most consistent of the three observers, and that N.D.M. is more consistent than M.L.T. though both reduce their variability on the second occasion, when less new to the job. That there are inherent differences between different observers in respect of observational variability is certain; and three observers form too small a sample for us to draw exact conclusions regarding the relative variability of the Breitinger and Macdonell techniques, as such, on the basis of the above nine estimates on the one hand (ranging from 1.97 to 5.62 cc.) and the estimates on the other hand of 5.96, 6.69, 7.48 and a doubtful 5.09 for Macdonell's technique. But as far as they go, the data certainly suggest that Breitinger's technique is not only the quicker, but also the less variable in its results.

We must now consider the mean capacities obtained from our meas urements of the red and blue test-skulls. As has been pointed out, al though Breitinger's description of his procedure is detailed, it stil leaves some parts open to individual differences of interpretation. N attempt was made beforehand to bring our interpretations into lin with one another, only the explicit directions being taken into account The following were the means of the first fillings:

FEB. 1942	MEAN OF REPEATED FILLINGS Red skull	Blue skull
M.L.T.	(30) 1176.7 ± 1.21 cc.	
N.D.M.	(30) 1178.1 ± 0.70 cc.	(30) 1670.0 ± 1.36 cc.

That they were so close for the red skull was evidently the result o chance, for the water-capacities which were obtained subsequently gav 1208 cc. for the red and 1697 cc. for the blue, showing that we had fille rather too loosely. We then experimented a few times with our inter pretations of the less well defined directions, until we had arrived a results closer to the water-capacities. The testing was then carried ou afresh, with the following results: —

MAR. 1942	MEAN OF REPEATED FILLINGS Red skull	Blue skull
M.L.T.	(30) 1206.0 ± 0.69 cc.	(30) 1698.4 ± 1.63 cc.
N.D.M.	(30) 1202.3 ± 0.53 cc.	(22) 1707.5 ± 0.95 cc.
Water-capacity	1208 cc.	1697 cc.

For neither skull does M.L.T.'s mean differ significantly from th water-capacity, and although N.D.M.'s means differ rather more, ther is little doubt that, given further opportunity of experimenting, h would be able without much difficulty so to modify his procedure, with in the limits left by Breitinger, as to arrive at the correct means fo skulls small or large. War-conditions, however, give less leisure tha before for such peaceful pursuits, and the considerable adjustments al ready made by both of us are sufficient evidence of the possible modi fications.

(f) Conditions for avoiding bias in measuring by Breitinger's tech nique. As in the case of Macdonell's technique, there are three condi tions to be fulfilled if Breitinger's is to give the mean capacities o different skull-series without observational bias: (1) the water-capacit of at least two test-skulls of widely different sizes must be accuratel determined; (2) such of Breitinger's instructions as leave room for dif ferences of procedure must be so interpreted as to give correct mea values for both skulls, from not less than about 30 fillings of each an

preferably more; — fifty is better because it gives a more reliable estimate of the s.e. of the mean value obtained. (3) Any subsequent unconscious tendency to modify the technique thus adopted must be checked by regular routine re-filling of the test-skulls.

As to the first condition, we have already mentioned some of the difficulties encountered in measuring the water-capacity of test-skulls, and we may here add another, with which we ourselves had to cope, namely imperfect proofing. The test-skulls of which we made use had been painted outside and varnished inside. The outside coatings had eventually been made thick enough to let no water through, but that did not seem to be the case with the inner lining, for after the skulls had been emptied of water and left standing a few minutes, water was found to have drained slowly back from some space into which it had percolated (possibly between skull and coating), making a little pool in the inverted skull. To arrive at our determinations of water-capacity, we had to fill the skulls and leave them long enough to become water-logged, then quickly empty and straightway weigh them to get the amount that must be deducted from the weight of the skulls when full of water.[8] We then weighed a measuring glass, first empty and afterwards containing 1000 cc. of water from the same tap, so as to get the weight-volume equivalent by which the weight of the water in the skull-cavity could be expressed in terms of cranial capacity. To how fine a unit it can be thus expressed, depends on the unit of weight to which the scales may be read accurately. There will be approximately the same number of cubic centimeters as of grams, and if the scales weigh correct to the nearest gram, the weight of water, which is obtained by differencing, will be correct to the nearest 2 gm. Obviously if the only available scales that weigh up to about 2 kg. can be read merely to the nearest decagram, the resultant capacity-measurement can only be taken as correct to the nearest 20 cc.; which is not much good. A 2000 cc. measuring glass is then better for the purpose.

As to the preparation of test-skulls, Mollison ('32) describes his method as follows:

"A strong skull, with well-preserved calvaria, when quite dry is soaked in paraffin-wax till the bone has absorbed all it can; it is then left to cool. The superfluous wax adhering to the surface is then scraped off with a wooden blade. This treatment closes all the small foramina in the bone and makes most of the sutures quite water-tight. The open-

[8] This was the best we could do, and any error would probably be small; but even if it were not our conclusions regarding Breitinger's technique would not be affected: as we have seen, our interpretation could have been modified to give a seed-capacity which agreed with the correct water-capacity.

ings in the base of the skull, at the back of the orbits, and in the lamina cribrosa are closed with putty which is smoothed down. The putty should not project into the skull, of course. It will be hard enough in a few days for the skull to be used. A skull thus preserved is not affected by being filled with water, and the process has this advantage over the former method of soaking in linseed oil, that one need not expect it to dry out gradually and cause the putty to shrink and crack easily."

If however the paraffin wax covers the inner as well as the outer surface of the skull, it may render the results obtained from the test-skull inapplicable to ordinary skulls. Stewart ('34), in studying on three skulls the effect of a smooth paraffin-waxed inner surface, found that where maximal packing was aimed at, 20–45 cc. more seed was packed in than when the skulls were in their natural state. Minimal packing, on the other hand, was unaffected by this change of surface. By the latter method, the seed was poured continuously into the skull, which until the frontal region was filled was kept tilted forward and was then gradually brought to the horizontal as filling neared completion. The only "packing" added to this procedure was the insertion of the index finger before filling was complete, to push the seed lightly into the temporal fossae. Breitinger's method, which packs with a density between these two extremes, may be affected by a waxed inner surface to some extent perhaps, though less than the method of maximal packing. Whether, while using paraffin wax as proofing material, one could keep it from the inner surface by putting a temporary plug in the foramen magnum and applying the putty to all the other openings before soaking the skull in the wax, is a matter for experiment.

The smaller of the two skulls used by Breitinger was waxed, but not the larger, prepared subsequently: —

A large skull was soaked, in the way described by Mollison, in the "positive-substance" used in our Institute for making casts. This compound of wax and rosin, which dries very quickly, proved very suitable for closing completely the sutures and foramina; the new test-skull was filled with water and stood half a day without losing a drop. With a cranioscope, such as Broca had already used, and a telescope light-bulb (Aichel, '31), one can easily satisfy oneself as to whether all foramina are in fact closed. If necessary some more of this substance can be painted on hot, and any unevenness in the deposit can be removed with a hot spatula. It is also advisable to paint the outside of the skull when dry with spirit-varnish, as otherwise the hands tend to stick to the thin layer of proofing substance when shaking the skull.

From an account by Rudolf Schwarz ('29) of the method of making casts to which Breitinger refers, we gather that the "positive-sub-

stance'' is called Hominit, and that it could be obtained from Apotela A. G., Zürich.[9]

So much then for the first condition for the accurate determination of cranial capacity by Breitinger's technique, namely the correct measurement of the water-capacity of suitably proofed test-skulls. The second condition is that the less exactly defined parts of his procedure should be experimented with, until the means of repeated fillings of large and small test-skulls agree with the respective water-capacities. The number of fillings of each should be not less than about 30, and 50 is still better because it gives a more reliable s.e. to the mean value obtained; also the observer should not rest content until he has a continuous series of recordings whose estimated σ is not higher than 5 cc. per 1000 of capacity, though in many cases it will be lower.

The third condition is that the procedure thus established should remain unchanged in practice. Breitinger recommended the re-measurement of a test-skull after every ten measurements of other skulls, and we would only amend this so far as to suggest that a large and small test-skull should be used alternately for the check. Also that, as these measurements are taken, they should be plotted on a sheet of graph-paper, on which has been drawn a datum line representing the water-capacity of the skull in question, and pairs of lines parallel to it and equi-distant from it above and below. The distance of the nearest pair

[9] As the new method of casting has many advantages — among others the fact that hair does not stick to it, which saves pain to living subjects, and makes possible the casting of such objects as the very hairy head of an ape, as one of us (M.L.T.) saw done at Munich — we have taken from Schwarz' account of it not only the part relating to the use of Hominit but also to the rest of the casting process: — ''After many years of research, Poller has perfected a new method of making moulds which has many advantages over methods used hitherto. The new moulding material, called Negocoll, is a hydrocolloid substance which at once solidifies when cooled but at the same time remains elastic and is for this reason specially suitable for casts from the living . . . One heats the Negocoll, carefully in an enamelled pan, stirring continuously until it is melted. Within ten minutes one can begin to lay on the Negocoll, which must not be too hot, of course . . . with a broad brush that can stand heat . . . If the paste becomes too thick, it must quickly be made a little warmer and the work continued until the layer is about 2 cm. thick . . . When made quite cold, by means of wet cloths, it can be detached . . . The preparation of the positive must be begun at once as the Negocoll mould begins to shrink after a short time. The positive-substances are called Hominit and Celerit. The light cream-coloured Hominit is specially suitable for the reproduction of parts of the human body. The Celerit, a substance resembling shellac, serves to strengthen the Hominit. A few cubes of Hominit are carefully warmed up in a small enamelled pan over the flame of a Bunsen burner and slowly melted, and the mould is then painted over by means of a small brush that can stand heat. When the whole mould is covered with a thin layer, strips of muslin, single or double, are laid on and painted over till the whole surface has been strengthened. Then the final layer, Celerit, prepared in the same way as the Hominit, is laid on. When the positive has become cold the Negocoll negative can easily be peeled off, and the cast is finished. At most there are small unevennesses due to air-bubbles to be trimmed off with a knife . . . This easy making of the positive I consider to be the greatest advantage of the new method. Casting with plaster is more difficult and takes much longer. There is a good deal of finishing to be done on a plaster cast, and the finer details of the skin are not shown up so well. It is easily damaged, whereas the Hominit cast stays in good condition, and as the latter is not more than 5 mm. thick it is lighter in weight and more easily stored.''

will represent $\pm \sigma$ when $\sigma = 0.005$ of water-capacity, the next pair will be ± 1.96 times this distance away and the third pair ± 2.58 times, representing respectively the limits of deviation which on an average will not be exceeded more than twice in forty times and twice in 200 times (once in excess, once in defect) with the given value of σ. If deviations beyond these limits occur with disproportionate frequency one must correct one's technique accordingly.

CONCLUSION

Hambly ('40), to whom we owe the repetition, on fifty of his New Guinea skulls, of capacity measurements by Macdonell's technique, urges that "more research should be concentrated on developing a quick technique for measuring the capacity of skulls;" and it was in the hope that the much quicker technique devised by Breitinger would prove to be not less accurate than Macdonell's that the present investigation was undertaken. That hope has been justified, and indeed such evidence as we have been able to collect suggests that Breitinger's method is the more accurate of the two. Accuracy has been compared from the viewpoints of bias and observational variability. As regards bias, we have seen that to avoid it in both techniques there must be correct determination of the water-capacity of suitably proofed test-skulls, a considerable number of measurements of the seed-capacity of these skulls — enough to give a reliable mean — and periodic re-measurement of them during the application of the technique to cranial series, so as to check any unconscious alterations of method. The conditions are the same for both techniques, but the fact that Macdonell's takes 20 minutes or so for each measurement of a test-skull discourages fulfillment. Then as regards observational variability the available data indicate that Breitinger's method is less prone to vary in its results. Finally there is the question of apparatus. Scales weighing accurately to a fine unit of measurement are the main piece of apparatus required by Macdonell's technique. Breitinger's dispenses with the scales, but it requires a funnel of given dimensions, a cylinder of given height and diameter, and a second cylinder fitting closely into the first. Breitinger's two cylinders, designed by Mollison, were made of brass, and the inner cylinder was used both to measure the quantity of seed in the outer cylinder and to contain the seed when not in use. These features however are not essential to the carrying out of Breitinger's directions: a graduated glass cylinder measuring to 2000 cc. would serve, if of the right dimensions, and a closely-fitting cylinder of wood to rest lightly on the seed (without any effort to flatten its surface)

would give the level from which capacity should be read off. This reflection raised a question regarding the usual dimensions of 2000 cc. glass cylinders, and a firm of manufacturers was visited to gain information on this point. Their cylinders, they stated, were made to no exact height and diameter though approximately equal in size, and a stock of them was shown. On measurement they were found to be very nearly of the same inner dimensions as Breitinger's technique stipulater (50 cm. in height, 73 mm. in diameter), so near as to be quite suitable for the purpose. Whether all manufacturers make them to these approximate dimensions is not known; but if a 2000 cc. glass cylinder is available to those wishing to measure capacity and not wishing to spend money, they may at least approach it, rule in hand, with some degree of hope.

In conclusion we wish to thank Mr. Little of the Duckworth Laboratory of Physical Anthropology at Cambridge for the facilities put at our disposal for our experiments; and one of us (M.L.T.) wishes also to express her indebtedness for the Leverhulme Research Fellowship which enabled her to carry out her part in this investigation and provided the apparatus used.

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ON SPECIES AND RACES OF LIVING AND FOSSIL MAN

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Important advances have recently been made in the study of man's ancestry and evolution. Particularly notable is the analysis of the interrelations of the known fossil and living hominids made by Weidenreich ('43) in his monumental series of monographs on the remains of the Peking man. Though made strictly from the point of view of a morphologist, Weidenreich's conclusions deserve careful attention of geneticists interested in the structure and evolution of human populations. For according to Weidenreich, the hominids have been in the past, as they still are, represented by a single species subdivided into several races or subspecies. This makes it desirable to review the whole problem of the evolutionary status of living and fossil man in the light of conceptions of modern genetics and systematics.

The opinion is often expressed that species and races are arbitrary categories. This opinion is false. If given the opportunity to secure the necessary data, a biologist is able in a majority of cases to decide beyond a reasonable doubt whether the forms under study are distinct species or only distinct races. Lion, tiger, leopard, and domestic cat are species; Angora cat and alley cat are surely not species but races. However, "borderline cases", in which it is impossible to decide whether one is dealing with species or with races, do exist. Indeed, their existence was used by Darwin to demonstrate organic evolution. If species are the primordial units of creation, or else if they arise by sudden leaps (as thought by G. St. Hilaire and recently by Goldschmidt), then we should be able to find methods to decide whether any two forms are still races or already species. If, on the other hand, species evolve gradually from races, then the decision will be possible only in some, perhaps in a majority, of cases, but at least some instances must be found in which forms are too distinct to be races but not distinct enough to be species. Evolutionists have concentrated their efforts on proving that such borderline cases do exist; by indirection they conveyed to biologists in general the impression that there are no other but borderline cases.

The evolutionary status of mankind was discussed by Darwin in "The descent of man". Darwin regards man as a systematic borderline case.

He is aware of "the weighty arguments . . . for raising the races of man to the dignity of species, and of the insuperable difficulties on the other side in defining them". The horns of this dilemma are used by Darwin in support of the contention that man is a product of evolution. We know at present that some of the "weighty arguments" were based on faulty information, while others do not have the significance that could be ascribed to them in Darwin's time. Modern man is definitely not a borderline case. It is a single species consisting of races so imperfectly differentiated that "the insuperable difficulties" in delimiting and counting them are now at least as great as they were when "The descent of man" was written.

Species in sexual cross-fertilizing organisms are defined as groups of populations which are reproductively isolated to the extent that the exchange of genes between them is absent or so slow that the genetic differences are not diminished or swamped. Races are defined as populations differing in the incidence of certain genes, but actually exchanging or potentially able to exchange genes across whatever boundaries (usually geographic) separate them. These definitions are evidently based on biological, and particularly on genetic, criteria. To distinguish species from races is, however, the chief business of systematists. Systematists perforce use morphological and geographic, and only very rarely genetic, criteria in their work. This undeniable fact has misled Weidenreich and some other writers into thinking that genetic criteria are useless in defining the species of systematists. As a matter of fact, genetic species definitions are important to systematists because they elucidate the real meaning of, and help in developing and perfecting, the operational criteria which systematists normally employ. Indeed, a reform movement has been going on in systematics for several decades, and is still under way, to introduce the general use of the polytypic species concept (see Mayr, '42). It is recognized that most living species are more or less clearly differentiated into geographic races, each race occupying a portion of the species distribution area. The races, otherwise known as subspecies, may be connected by transitions in geographically intermediate zones, or they may be separated by migration barriers and fail to show morphological connecting links. Racial differences can not persist if races come to inhabit the same territory, for in such a case the races, lacking reproductive isolation, would exchange genes, the differences between them would gradually be erased, and finally they would fuse into a single variable population.

If forms differing in several characters (more precisely: in several genes) coexist in the same territory, and the differences between them,

however slight, do not disappear in the course of time, these forms are evidently isolated reproductively, and hence must be regarded as distinct species (sympatric species). The experience of systematists shows that, given adequate material, no difficulty is encountered in delimiting sympatric species. Species living in different territories (allopatric species) furnish most borderline cases. Races which occur in remote parts of the species territory may show as great, or even greater, morphological differences as sympatric species of the same genus or family do. If such races are connected by intergrades in the geographically intermediate territories, they are considered races regardless of the magnitude of the morphological differences. The presence of intermediates is presumptive evidence that the extreme races are united by gene flow through the intermediate links, and, therefore, are unlikely to be isolated from each other reproductively. (Instances of "rings of races" are, however, known in which the extreme races coexist in the same territory without mixing, and yet are connected by intermediates living in other territories; such instances furnish some of the most beautiful "borderline cases" between race and species (cf. Mayr, '42).

It is when no intergrades between the inhabitants of different countries are observed that the decision on the race-species issue becomes difficult. The systematist usually has no way of knowing whether and to what degree the forms in question are reproductively isolated; he can proceed only by inference. He estimates the magnitude of the morphological gap between the allopatric forms in question, and compares this gap with the gaps usually encountered between known sympatric species of the same genus or family. If the gap between the allopatric forms is as great as or greater than that between related sympatric species, the former are regarded as distinct species; otherwise they are considered races. This method evidently boils down to an estimation of the probability that reproductive isolation may have developed between the allopatric forms under consideration. The limitations of this method are evident, but it remains the only recourse open to a systematist when experimentation is impractical. The "morphological species" are inferences of the "genetic" species actually existing in nature (Simpson '43). Darwin's oft quoted saying that in distinguishing species from races "the opinion of naturalists having sound judgment and wide experiences seems the only guide to follow" remains true today, but not all those who quote it have a clear idea of what this adage means. For at least in our day, it is in making the estimates and comparisons of the magnitudes of the morphological gaps

between sympatric and allopatric species that the experience, judgment and artistry of a systematist come into play.

In the light of the above definitions, living mankind is evidently not a "borderline case" but a single species, Homo sapiens, differentiated into races so poorly delimited that their very number is estimated from two to about one hundred. It is true that populations of geographically remote territories sometimes appear strikingly different in their external and partly also in their skeletal characters; but such different races are connected by intergrades which usually inhabit geographically intermediate territories. The presence of the connecting links between the racial extremes is presumptive evidence that the gene flow from race to race is obstructed not by any forms of reproductive isolation but only by the geographical separation. If mankind were an ordinary biological unit, the above evidence would be regarded by any modern systematist sufficient to rank it a single polytypic species.

In the case of man, some additional evidence is available. Wherever and whenever human races come in contact in the same territory, they mix and exchange genes more or less freely. There is no indication of either lessened viability or of sterility of hybrids. Caste and class barriers sometimes impede the free gene flow from race to race, but it is doubtful if these barriers can justifiably be compared with sexual isolation as the latter exists on the biological level. Be that as it may, it is certain that none of the existing caste and class barriers are strong enough to reduce the gene exchange between the human races to a point where the racial differences might remain constant or even increase in the course of time. It is quite possible that before the dawn of civilization the human races were diverging, and might have eventually become separate species if this process of divergence would have been allowed to go on. But it is quite certain that species separation has not been reached. On the contrary, civilization has very early reversed the process; first a gradual and recently a much more rapid gene exchange has set in, tending toward eventual fusion of the races in a single greatly variable population. Despite the attempts of the Nazis and their imitators, it may be doubted that this trend can ever be reversed again.

Nevertheless, opinions are voiced from time to time that mankind is not a single but a group of species (e.g. Osman Hill, '40). These opinions are due to unfamiliarity with or to misunderstanding of the polytypic species concept of the modern systematists and the race and species definitions based on genetic considerations. After all, any term in science, including the term "race" and "species", means only what we make it mean. The time is not far past when many systematists

designated as species any two populations which they could (or thought that they could) distinguish by examining the morphology of a single specimen. To quote an example of this in a group of animals not very remote from man — Elliot ('12) recognized as many as ten species of chimpanzee instead of a single one! Lately such extravagances are becoming rare, but conservative systematists still cling to a purely morphologic species concept. Those who misunderstand the genetic race and species concepts are prone to point out that undoubted species sometimes produce a few hybrids in nature, or can be made to do so in laboratories or in captivity. As far as gene exchange between populations of two species is concerned, the behavior of these species in the laboratory is irrelevant; if fertile hybrids are occasionally born in nature, it is the frequency of these hybrids which is important. For if the gene exchange is slow enough, then the species populations may continue to diverge. The human races exchange genes at rates which cause their convergence, which, as pointed out above, not only prevents these races from ever attaining the species level but even from remaining constant.

Excepting certain phenomena, such as polyploidy, which need not be considered in discussing the evolution of man, the process of evolutionary divergence is in general too slow to be noted in a lifetime. A systematist of living organisms observes the results of the evolutionary process and not the process itself. This is why we find full-fledged species, undoubted races, as well as "borderline cases". There are some indications that, although races and species diverge slowly and gradually, the transformation of race into species (i.e. the development of reproductive isolation) entails a sort of an evolutionary crisis, which is relatively rapid. Forms caught in the midst of this crisis at our time level are a minority, although they are more numerous in some groups than in others. While a systematist of living organisms observes, so to speak, a single snap-shot of the evolution of life, the paleontologist aspires to obtain a series of snap-shots, which should add up to a motion picture.

Paleontologists describe (a) "horizontal" species and races among the forms which existed on the various time levels for which data are available, and (b) "vertical" species and races which are formed owing to the changes which a given organism undergoes in the course of time. It might seem that classification of fossils can be based only on morphological criteria, and that genetic concepts and methods are of no relevance to paleontology. Thus, Weidenreich ('43) assures us that "no interbreeding will ever decide whether there is a relationship

between 'Eoanthropus' and an Englishman or between 'Eoanthropus' and an anthropoid or of what kind such relationship may be.'' The applicability of genetic concepts needs not, however, be understood so naively. According to Simpson's ('43) excellent formula, ''a taxonomic species is an inference as to the most probable characters and limits of the morphological species from which a given series of specimens has been drawn,'' while the ''morphological'' species is an inference of the ''genetic species.'' In describing ''horizontal'' species the paleontologist may use essentially the same methods which are used by neontologists, although additional difficulties are evidently encountered in the work with fossils (Simpson, '43). Sympatric species which existed on a given time level are established first, then the magnitude of the morphological gaps between them is estimated, and finally allopatric species are delimited by comparison with the sympatric ones. In some groups of fossils, as well as in some living organisms, the material available may be, and frequently is, not adequate to reach conclusions that may be relied upon. It must be realized very clearly that in some groups of organisms the species and races are established with a much greater degree of assurance than in other groups, in which the ''species'' are only temporary devices useful for making a rough catalogue of the information on hand (for a discussion of this see Mayr, '42, and Camp and Gilly, '43). But this is no reason for obstinate retention of outmoded ideas about the nature of biological species and the methods of studying them.

Since the criterion of reproductive isolation is clearly inapplicable to organisms separated in time, the definitions of species and races based on this criterion (see above) do not directly bear on the ''vertical'' species of the paleontologists. In practice, the incompleteness of the geological record is made use of in making ''vertical'' classifications: the gaps in the fossil series subdivide the continuous succession of forms into discrete sections. The practical question is, then, how ''long'' should be the sections called species in contrast to those called races? According to Simpson ('43) ''successive taxonomic units are inferences as to morphological units such that the net difference in morphology between corresponding parts of those units is of the same order as that between horizontal units of the same rank in the same or allied groups.'' This convention has the advantage of at least indirectly referring to a phenomenon of an undisputed biological significance — reproductive isolation between populations of sympatric species.

Although the material on fossil hominids has recently increased owing to several highly important findings having been made during the de-

cade preceding the war, it can not be gainsaid that the data available remain unsatisfactory. Fossil specimens are usually odd bones or bone fragments; this raises endless difficulties in reconstruction and interpretation. The timing of some of the fossils is inexact or difficult to correlate with that of others. No specimens have yet been found in extensive, and possibly critical, sections of the world. Nevertheless, some facts and theories have emerged which seem to call for a commentary from the viewpoint of genetics. The works of Hrdlička ('30), McGregor ('38), McCown and Keith ('39), and Weidenreich ('43) have been used as principal sources for the following discussion.

The recently discovered remains of several individuals of Peking and Java men make the second Glacial period the earliest time level for which a reasonably abundant material on fossil hominids is available. Despite the earlier doubts, it seems now certain that the differences between Peking and Java men are easily within the magnitude range of the differences between the living human races. Therefore, these forms represent two apparently rather closely related horizontal races of the same biological species, Homo erectus.[1] What kind of humans lived at the same time in parts of the world other than Java and China, is an open question. The remains of the alleged "Piltdown Man" are distinct from and older than Homo erectus, but it now seems fairly clear that these remains are a mixture of ape and human bone fragments. The Heidelberg man, the Swanscomb, Steinheim, and the so-called "Africanthropus" remains are either too fragmentary or too insecurely dated to furnish a safe basis for classification. Only one thing is certain — the populations of Europe and Africa were not identical with those of Java and China. The human species was then, as it is now, differentiated into geographic races.

During the third interglacial (Riss — Würm) and the last glacial periods Europe was inhabited by Neanderthal men, known as Homo neanderthalensis (= primigenius). This is the best known of the fossil hominids. Morphologically, it is not strictly intermediate between Homo erectus and modern man, but shows what Weidenreich describes

[1] In his 1940 paper, Weidenreich denotes Java man and Peking man as Homo erectus javanensis and Homo erectus pekinensis respectively (the name Homo erectus erectus would be the correct one for the former). But in 1943 this author relapses into the use of the misleading names Pithecanthropus erectus and Sinanthropus pekinensis, continuing to admit that they represent only races and not separate species or genera, and arguing that these are "just names without any 'generic' or 'specific' meaning." Unfortunately, these names do connote a generic and a specific, rather than a recial, difference to anyone familiar with the biological nomenclature. The abuse of generic and specific names by students of the hominid evolution is notorious; it is making this fascinating field rather bewildering to other biologists.

as "an intermingling of primitive and advanced characters." The Neanderthalians were differentiated geographically. Weidenreich distinguishes four subgroups (horizontal races?), living respectively in Central and Southern Europe, Palestine, and South Africa (the last of these, the Rhodesian man, is so distinct from the more northern subgroups that other authorities do not consider him close to the Neanderthalians; its age is also uncertain, so that both a horizontal and a vertical race may be here involved). The Neanderthal man in Europe disappeared rather abruptly during the last glacial period, being replaced by a type which definitely belongs to Homo sapiens. Where this Homo sapiens came from is obscure, but the lack in Europe of an obvious transition between Homo neanderthalensis and H. sapiens, two forms which were at least for a brief interval contemporaneous, could be used as an argument in favor of considering them distinct species. The replacement of Neanderthal man by Homo sapiens seems to resemble the instances known in biology when a better adapted species invades the territory of a less well adapted one, and displaces the latter without mixing with it. To be sure, some anthropologists (e.g. Coon, '39) believe that the now living populations of some corners of Europe display certain characteristics derived from the Neanderthalians. The evidence on which this view is based is, however, not conclusive.

Fortunately, the problem of the biological status of the Neanderthal has been elucidated by the remarkable findings of McCown and Keith ('39) on Mount Carmel in Palestine. These authors have described an extraordinary fossil population, which lived apparently during the third interglacial period, and which consisted of individuals ranging from a typical Neanderthalian to a Homo sapiens with some characteristics of the former. The interpretation of this great variability given by McCown and Keith is that the Mount Carmel population was "in the throes of evolutionary change," with the Neanderthalian and the modern types emerging from an ancestral form. The improbability of this view, even on the assumption that the Neanderthalian and the modern types differed in a single gene, has been pointed out by Ashley Montagu ('40). Since this difference was doubtless a resultant of numerous interacting genes, the interpretation of McCown and Keith is excluded. Indeed, two types differing in a system of genes can not crystallize out of a mixed population without the interbreeding of these types being prevented by a spatial separation. The Mount Carmel population arose, therefore, as a result of hybridization of a Neanderthaloid and a modern type, these types having been formed earlier in different geographical regions. It is evidently improbable that a rare instance of species crossing has been preserved on Mount Carmel;

hybridization of the Neanderthalian and the modern forms must have been a frequent occurrence, at least in Palestine and at the time when the Mount Carmel population lived. Therefore, the data of McCown and Keith prove something very different from what these authors themselves thought they demonstrated, namely that the Neanderthal and the modern types were not isolated reproductively, and, hence, were races of the same species rather than distinct species. This shows how rash are the assertions of some writers that in fossil forms evidence on presence or absence of reproductive isolation can never be obtained!

Whether the Peking and Java men were specifically, or only racially, distinct from the Neanderthalians, is an open question. This question might be settled some day by findings analogous to that made on Mount Carmel. Otherwise, the future work may disclose that at a certain time level populations resembling the Peking, the Neanderthal man, as well as populations intermediate between the two, existed simultaneously in different parts of the world. This would constitute a presumptive evidence of a specific unity of the Peking and the Neanderthaloid types.[2] The Mount Carmel population also shows that, in Hominidae, a morphological gap as great as that between the Neanderthal and the modern types may occur between races rather than between species. This is useful information for builders of horizontal as well as vertical classifications of fossil hominids.

There are several insufficiently known fossil types which differ both from the living Homo sapiens and from the fossil Homo erectus and Homo sapiens neanderthalensis, without being strictly intermediate between any two of the latter. Here belong the already mentioned Heidelberg, Steinheim, and Swanscombe remains from Europe, "Homo soloensis" from Java, and "Africanthropus" and Rhodesian man from Africa. Paleoanthropologists are far from agreed about the nature and significance of these types. Two trends of thought are marked. The first view, which may be called the classic one, assumes that the course of the hominid evolution has been steadily divergent, producing a phylogenetic tree with many branches. The known fossils represent mainly some of the branches, and only rarely the main phylogenetic trunk. All the branches but one withered and became extinct; the sole surviving branch is the present Homo sapiens. This branch has, in

[2] It should be emphasized that such an evidence, if obtained, would not necessarily indicate a specific unity of the Peking and the modern types, even though we know that the modern and the Neanderthaloid types should be classed as subspecies of the same species. The "rings of races" mentioned above show that forms A and B, as well as B and C, may behave as races, while A and C behave as distinct species. This paradoxical situation is a consequence of the fundamental continuity of the evolutionary process.

turn, split into diverging twigs — the present human races. The second view, set forth very ably by Weidenreich, supposes that during the Pleistocene different strains of the human species, in different regions and at different speeds, were independently passing through the same general series of evolutionary "stages" leading from an anthropoid to the modern human type. The racial differentiation of living mankind has its roots at a level much antedating the attainment of the Homo sapiens "stage." Thus, the Java man is linked through "Homo soloensis" to the Australian aborigine; Peking man leads, through an unknown Neanderthaloid form, to the Mongolian race, just as the Rhodesian man might have given rise to certain African and the European Neanderthal man to certain European races. Homo erectus, the Neanderthalians, and other fossil types have not disappeared without issue — their offspring became transformed into the living humanity.

Weidenreich's theory has a superficial resemblance to Klaatsch's notion of a polyphyletic origin of man from orang-like, gorilla-like, and chimpanzee-like ancestors. This notion breaks down because the now living orang, gorilla, and chimpanzee are unquestionably separate species, apparently completely isolated reproductively. It is highly unlikely that full species could converge to such an extent that the human races derived from them show no reproductive isolation at all. If, on the other hand, the potentially human offshoots of orang, gorilla, and chimpanzee separated before these forms themselves became reproductively isolated and specifically distinct, then it is misleading to speak of ancestral forms resembling the now living species. Weidenreich's theory is, however, free of such objections as the above, because this author expressly states that "the hominids have formed — and still form — one family or, in a strictly taxonomic sense, one species and are all more or less related to each other in spite of manifold regional variations." In genetic terms this would mean that only geographic segregation, and none of the several known forms of reproductive isolation, kept apart from each other the different branches of the human species. A mutation or a genotype arisen in any one place is potentially able to reach all other human populations. Weidenreich's is a theory of parallel development of races, not of species.

The question now arises why several hominid races, living in parts of the world with quite different climates and environments, have all gone through similar series of changes leading from Homo erectus, through a Neanderthaloid, and to the modern Homo sapiens stage. Weidenreich ('41, '43) attempts to answer this by an ingenious theory which correlates the changes in several "characters" with a single fundamental trend — a gradual increase of the brain size. This

becomes, however, a theory of orthogenesis, and Weidenreich very wisely refrains from guessing what were the causative agents which impelled different races of a species to evolve independently but asynchronously in the same direction. The problem of possible genetic interpretations of orthogenesis is too complex to be discussed here; the truth is that geneticists prefer to avoid assumptions of inherent orthogenetic trends, unless proof is forthcoming that such assumptions are necessary. There is no such proof in the case of hominid evolution. The basic fact which leads Weidenreich to assume parallel evolution of races, is the presence of morphological traits binding the major racial subdivisions of the living Homo sapiens to the primitive hominids which resided in the corresponding geographic regions during the Pleistocene. This interesting fact may, however, be accounted for in different ways. The environment prevailing in different parts of the world may favor, through a process of selection, the development in the inhabitants of these parts of certain morphological characteristics. Or else, hybridization of members of invading and indigenous races may permit the retention in a population of a country of some characteristics derived from remote indigenous forbears.

The classic theories of hominid evolution assume, in contrast to the parallel evolution theories, continuous radiation and divergence of human types. Adherents of these theories have disqualified one after the other the known fossil types as progenitors of the now living Homo sapiens, reducing these types to the status of mere "side branches" of the hominid trunk. As Howells ('42) correctly says: "the more dominant the factor of evolutionary radiation is taken to have been, the less reason there is for assuming any connection at all between modern man and fossil forms, except only through a remote common ancestor." Whence our ancestors came and when, what they were like, and how this hypothetical stock split up into the existing races remains undecided. All the known fossil forms, except for some relatively very recent ones (Cro-Magnon, Grimaldi), are assumed to have been replaced by the hypothetical immigrants without mixing with the latter to an appreciable extent. This implies the assumption of reproductive isolation between these forms.[3] Yet, as far as known, no more than a

[3] Such an assumption would at least make the classical theories self-consistent. Actually, most authors qualify the descriptions of their fossil "species" and "genera" by protestations that they do not suppose these species to be "mutually sterile." This is followed by suppositions that these species are replaced in time and in space by other species, with little or with no hybridization. Now, sterility is, of course, only one of the several known reproductive isolating mechanisms. This shows that an understanding of the biology of speciation is necessary for a valid interpretation of the hominid evolution. The distinction between species and races is not merely a matter of words or of convenience.

single hominid species existed at any one time level. All the phylogenetic transformations in Hominidae were always taking place within a single genetic system, a species consisting of geographically, but not reproductively, isolated races. Such a system is more plastic in the evolutionary sense than systems composed of several competing species.

When a species splits up into geographic races, these races diverge, develop reproductive isolation, and become separate species, it is possible to say that each one of the derived species arose in a certain part of the distribution region of the ancestral one. But when, as is apparently the case in hominids, a single species changes in the course of time, the species existing on a given time level may have been derived either from a part or from the whole of the species which existed on the preceding time level. Therefore, there is no a priori need to assume that the character and gene complexes which are collectively known as the modern species Homo sapiens arose in any one place or at any particular time. Favorable mutants occur repeatedly and in different parts of the distribution area of a species. Gene combinations superior to the prevalent types may also arise in various places and at different times, although the more complex a gene combination is the less probable becomes its independent and repeated origin.

A well adapted gene combination may form a local race, which may subsequently spread by supplanting other local races. But in a large and widely distributed species, many local races in different parts of the area are likely to be in the process of expansion at any given time, while other local races are contracting. The expanding strains which contain different evolutionary improvements may eventually meet and hybridize. Types possessing combinations of advantages originally present in several separate strains may be produced owing to Mendelian recombination. A type which arises in a certain territory is thus built of elements which came into existence in other territories. It may be noted that the expansion of a local race at the expense of others may take place, on the animal as well as on the human level, either by peaceful (hybridization, marriage) or by violent means (inter-racial struggle, war). The expanding race is, however, likely itself to undergo changes in the process of expansion, because of interbreeding with members of other races and because of settling down in territories with different environments. At any one time the species is likely to consist of a multitude of diverse racial strains, none of them "pure".

The conception that the modern Homo sapiens arose in some definite place, then spread the world over destroying outright all other hominid strains, and finally split up into races which in turn proceeded to di-

verge from each other, is probably an oversimplification of the actual story. Weidenreich is almost certainly right when he asserts that several (perhaps even all?) known fossil hominids are actual ancestors of the living mankind, but it is hardly necessary to assume that each fossil type became transformed into a definite human race. The contributions of the ancestral types to the gene pool of the species have been broken up and recombined by the sexual process, as well as sorted out by natural selection, before they became incorporated into the modern racial genotypes. The "classic" theory is probably justified to the extent that some of the races of the past have contributed more germ plasm than others to the formation of the present humanity.

Many parts of the Old World were inhabitated during the Pleistocene by some hominid forms. The distribution means which man possessed at the dawn of civilization were, however, quite imperfect compared to the ones developed later. Even though the mankind was genetically a single system, a race inhabiting a certain territory during the Pleistocene might have remained unaffected for a long time by the genotypes emerging in far away parts of the species area. The Neanderthal race had lived in Europe for some 100,000 years before being displaced 25,000–30,000 years ago by types approaching the modern ones. The present population of Europe is descended from these relative newcomers to a greater extent than from the Neanderthalians; where the former came from is unknown, but some parts of Asia seems the likely source. Yet, there are some indications that the inhabitants of the pre-Neanderthal Europe had some rather "advanced" human characters. It is possible, then, that the carriers of these advanced characters were first displaced in Europe by the Neanderthalians, then their progeny acquired some further "advanced" traits by crossing with some non-European strains, and lastly returned to Europe to displace the Neanderthalians. The genes which compose the genotype of the modern mankind have quite probably arisen in different parts of the world and at different times. The gene patterns characteristic of the modern humanity might have appeared either rather suddenly in some particular region, or they might have been arrived at gradually in many parts of the world inhabited by the ancestral hominid species.

We have spoken of the expansion of local races possessing superior adaptations to the environment, and of contraction of less well adapted types. Yet, anthropologists are generally of the opinion that most racial characters in man have no adaptive value. Thus, Howells ('42), apparently blissfully unaware of the difficulties so incurred, says: "the great majority of racial features are obviously not adaptational, and

consequently bespeak a more or less random fixation of random variations''. This amounts to rejection of the simplest hypothesis which can account for the origin of racial differentiation, namely that it is brought about, at least in part, by natural selection of genotypes possessing adaptive values higher than other genotypes in the environments in which the species normally lives. The process ''of random fixation of random variations'' in populations of limited genetically effective size may, as shown by Sewall Wright, be highly important in evolution (see Dobzhansky, '41). This process, known as the genetic drift, may explain certain types of racial divergence (e.g. the variations in the frequency of the blood group genes A, a^B, a). In conjunction with selection, the genetic drift becomes a powerful evolutionary agent, since under certain conditions it makes the species more plastic in the evolutionary sense than a form controlled by a rigid selection alone is likely to be. But it is very improbable that the genetic drift alone, not aided by any form of selection, could account for the whole or even for a major part of the racial differentiation in Homo sapiens. This supposition would become fantastic if invoked to explain the whole evolution of Hominids.

The lack of reliable data on the adaptive significance of the characteristics distinguishing the human races is, in the opinion of the writer, the greatest gap in our understanding of hominid evolution. This is a very important, but very difficult, field for future investigations. Indeed, most racial characters, especially the visible external ones, seem altogether too trifling to assist or hinder the survival or reproduction of their carriers in any way. Yet, it is possible that careful investigation might disclose these characteristics to be connected with some physiological properties having some, at least slight, adaptive value. The inference of Weidenreich ('41), that the increase of the brain size entails a series of structural modifications in the human skeleton, offers very interesting possibilities, because it indicates correlation between a highly important adaptive property and some characters which by themselves seem to be adaptively neutral. In discussions of this problem it should always be kept in mind that no life-or-death utility is needed for a trait to be sensitive to selection pressures. Similarly, it should be realized that on the human level various forms of selection dealing with tastes, preferences, prejudices, as well as the sexual selection in the strict Darwinian sense may be very effective. The range of characters which may be subject to these cultural and sexual forms of selection may be great indeed.

SUMMARY

1. Species in sexual cross-fertilizing organisms can be defined as groups of populations which are reproductivly isolated to the extent that the exchange of genes between them is absent or so slow that the genetic differences are not diminished or swamped. Races are defined as populations differing in the incidence of certain genes, but actually exchanging or potentially able to exchange genes across whatever boundaries separate them.

2. The above definitions are evidently based on genetic criteria. The "morphological" species and races are inferences of the "genetic" ones, just as "taxonomic" species and races are inferences of the "morphological" ones.

3. Living mankind is a single polytypic species.

4. On the basis of the available data there is no reason to suppose that more than a single hominid species has existed on any time level in the Pleistocene. Particularly, the findings of McCown and Keith on Mount Carmel prove that the Neanderthal and modern types were races of the same species rather than distinct species.

5. If the hominid evolution took place within a single species subdivided into races, the differences between the classic theories of evolutionary divergence and Weidenreich's theory of parallel evolution of hominid stems do not appear very serious.

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BLOOD GROUPS, SUBGROUPS, M-N AND RH TYPES OF CHINESE [1]

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In a previous paper (Wiener, Belkin and Sonn, '44), a comparative study was presented of the distributions of the various blood group factors among Negroes and Whites in New York City. Recently, we had the opportunity to carry out a similar study on Chinese, most of whom came from Southern China. The purpose of the present paper is to record our findings on a series of 138 Chinese bloods.

MATERIALS AND METHODS

The individuals supplying the blood samples used in this investigation were all presumably full-blooded Chinese who came to the Chinese Blood Bank as volunteer donors, to give blood to be used in the preparation of dried plasma. At the time when the blood was drawn, 5 cc. were collected in a separate tube containing 1 cc. of 3.8% dihydric sodium citrate solution. These blood samples were stored in the refrigerator without the addition of any preservative. The blood samples were tested after intervals of 5 to 10 days.

Though some of the samples were 7 or more days old when examined, only a few of the bloods were hemolyzed or were in such poor condition that they had to be discarded. On the whole, the reactions were clear-cut, despite the differences in age of the blood samples.

The technique of the tests has been described in detail elsewhere (Wiener, Sonn, and Belkin, '44; Wiener, '43), and will, therefore, not be repeated here.

RESULTS

As in the preceding paper, the results of the blood grouping, subgrouping, M-N, and Rh tests will be presented and discussed in the order named.

Blood groups and subgroups. Table 1 presents the distribution of the blood groups of 138 Chinese and, for comparison, a previously reported series of 1077 Whites.

[1] Aided by a grant from the United Hospital Fund of New York City, and a grant from the Carnegie Foundation through the Committee on Human Heredity of the National Research Council.

The most striking new finding is the complete absence of subgroup A_2 among Chinese individuals, in contrast to the situation in Whites where as many as one-fourth of the individuals of groups A and AB belong to subgroups A_2 and A_2B, respectively. It is of interest to note that a similar distribution of the subgroups has been encountered in tests on Polynesians (Nigg, '30), American Indians (Matson, Levine and Schrader, '36; Landsteiner, Wiener and Matson, '42), and Eskimos (Sewell, cited after Boyd, '39a). Except for the Polynesians, these groups, like the Chinese, are a part of the Mongolian race.

Our blood group data on Chinese exhibit the high frequency of gene *B* that is a well-known characteristic of the Mongolian race.

TABLE 1

Blood groups and subgroups among Chinese.

SERIES	NUMBER OF INDIVIDUALS TESTED		GROUPS AND SUBGROUPS						FREQUENCIES OF GENES			
			Group O	Group A		Group B	Group AB					
				A_1	A_2		A_1B	A_2B	p_1	p_2	q	r
Chinese												
New York City (present study)	138	Number	43	45	0	38	12	0	23.4	0	20.2	55.8
		Per Cent	31.2	32.6	0	27.5	8.7	0				
Whites												
New York City [1]	1,077	Per Cent	41.7	29.0	8.9	13.9	5.2	1.4	18.1	6.5	10.0	64.6

[1] Wiener and Sonn, cited by Wiener ('43, p. 323).

In the very first study on the racial distributions of the blood groups by the Hirschfelds ('19), these workers pointed out the progressive increase in the frequency of gene *B* as one proceeded from West to East in Eurasia. Bernstein ('32) has pointed out that the highest q values (above 30), where q represents the frequency of gene *B*, occur in Central Asia, particularly in the vicinity of the Indus and Ganges Rivers. If one proceeds from this center in all directions, whether North, South, East or West, one notes a progressive decrease in the q values, with only a few significant exceptions. The chief exceptions, as Bernstein points out, are (1) nomads, such as the gypsies in Austria, the Tartars at the mid-point of the Volga River, and the Kalmucks on the Northwest coast of the Caspian Sea; and (2) islanders, such as the Polynesians and Ainu, where the effect of isolation and intermarriage of small groups has altered the blood group distributions. This suggests that gene *B* arose by mutation in Central Asia, whence it spread throughout the world in all directions (cf. Candela, '42).

As far as China is concerned, Bernstein states that there is a pro-
;ressive fall in the frequency of the B gene as one proceeds from North
o South. Significantly higher q values have been reported for North
'hina than for South China, the dividing line being taken as the Yangtze
Iver. For example, Backiang-Liang (cited after Bernstein, '32) in a
eries of 1000 individuals found:

North China: $p = 19.9$; $q = 20.4$; $r = 59.2$
South China: $p = 20.1$; $q = 16.0$; $r = 63.7$

nd Yang (cited after Bernstein, '32) found in a series of 5435 indi-
iduals:

North China: $p = 20.6$; $q = 19.5$; $r = 59.4$
South China: $p = 21.3$; $q = 15.0$; $r = 65.2$

It is interesting to note that for Peking the q values have been re-
orted to be as high as 25.8, which is in conformity with its extreme
orthern location close to the Great Wall.

If, as Bernstein believes, gene B comes from Central Asia, the ques-
ion arises how and when gene B was introduced into China. The exact
rigin of the Chinese is not known.[2] Some authorities assert that they
riginated in the Tigris-Euphrates valley, while others hold that the
'hinese as well as the earliest civilized inhabitants of Mesopotamia
ame from Central Asia. The first historical records relating to the
'hinese date from about 2000 B. C. As the Chinese expanded south-
vard to the Yangtze River and to the sea on the East, they conquered
nd assimilated certain aborigines. From earliest historical times,
noreover, when the Chinese people were mostly located north of the
'angtze River, they were subject to invasion by peoples living to the
orth and west of them. On the other hand, during certain dynasties,
he Chinese in turn invaded the surrounding country, extending their
nfluence at times as far west as Mesopotamia and as far East as Korea.
'he most significant invasions occurred between the third and fifth
enturies A. D., when the Tatars and Tibetans extended as far south
s the Yangtze River, and in the thirteenth century when the Mongols
nvaded China. At any rate, if Bernstein's theory is correct that the
B gene was introduced into China from Central Asia, there was ample
pportunity for this to occur during historic times. It is not possible
o say whether the Tatars, Tibetans, or Mongols were chiefly re-
ponsible, or if they all contributed in equal degrees. Undoubtedly, the
ecent wholesale dislocation of populations caused by World War II
'ill cause further geographical changes in the blood group distributions.

[2] The historical discussion presented here is based on facts presented in the article on China
the Encyclopaedia Britannica (14th ed., '36).

A few remarks concerning the American Indians may be of interes in view of their supposed Mongolian derivation. While most tribes Amerindians belong to group O, some have been found to possess var ing amounts of group A (Matson and Schrader, '33; Boyd, '39b). already mentioned, however, all the group A individuals belong subgroup A_1, while genes A_2 and B appear to be lacking. This sugges that the American Indians separated from the main Mongolian trunk prehistoric times before gene B was introduced from Central Asi The existence of tribes of American Indians with high frequencies subgroup A_1 would therefore suggest the greater antiquity of this ge among the Chinese, while gene B was probably introduced into Chin far more recently.

TABLE 2

M-N types among Chinese.

POPULATION	NUMBER OF INDIVIDUALS TESTED		TYPES			FREQUENCIES OF GEN	
			M	N	MN	*m*	*n*
Chinese, N.Y.C. (present study)	138	Number	44	30	64		
		Per Cent	31.9	21.7	46.4	55.1	44.9
Whites, U.S.A.[1] (mostly N.Y.C.)	6,129	Per Cent	29.15	21.25	49.6	54.0	46.0
Chinese, Hong Kong[2]	1,029	Per Cent	33.2	18.2	48.6	57.5	42.5
Chinese, Cantonese (Boston)[3]	101	Per Cent	38.6	15.8	45.5	61.4	38.6

[1] Cited from Wiener ('43, p. 326).
[2] Ride ('35).
[3] Alley and Boyd ('43).

M-N Types. In table 2 are presented our data on the distributio of the M-N types in a series of 138 Chinese and, for comparison, som previously reported studies on Chinese and also some data on Ne York City Whites. The difference in incidence of genes M and N i Chinese, as compared with Whites is small and not statistically sig nificant. Additional studies on larger series of Chinese would be d sirable.

Rh Types. In table 3 are listed the results of tests on our series 138 Chinese bloods with standard anti-Rh_0, and with anti-Rh′ serun together with similar data on Whites and American Indians. It wi be seen that our results agree closely with those reported by Levin and Wong ('42) in that the incidence of negative reactions with bot sorts of sera is much lower in Chinese than in Whites.

Of the seven Chinese bloods giving negative reactions with the anti-Rh′ serum, all but one reacted strongly with anti-Rh″ serum. Of the 138 Chinese tested, therefore, two belong to the Rh-negative type, one to type Rh_0 and six to type Rh_2. Of the remainder the great majority were of type Rh_1 while the balance belonged to type Rh_1Rh_2.

TABLE 3

Rh factors among Chinese in New York City.

POPULATION	NUMBER OF INDIVIDUALS TESTED		TESTED WITH STANDARD ANTI-Rh_0 SERUM		TESTED WITH ANTI-Rh′ SERUM	
			Positive	Negative	Positive	Negative
Chinese, N.Y.C. (present study)	138	Number	136	2	131	7
		Per Cent	98.5	1.5	94.9	5.1
Whites, N.Y.C.[1]	622	Number	541	81	440	182
		Per Cent	87.0	13.0	70.4	29.6
Chinese[2]	150	Per Cent	99.3	0.7	93.0	7.0
White[3]	334	Per Cent	85	15	73	27
American Indians[4]	119	Per Cent	99.2	0.8	.....	.....
	69	Per Cent	.....	....	58	42

[1] Wiener, Sonn, and Belkin ('44).
[2] Levine and Wong ('42).
[3] Levine ('42).
[4] Landsteiner, Wiener, and Matson ('42).

TABLE 4

The eight Rh blood types and their approximate distribution among Whites in New York City.[1]

CLASSES		REACTIONS WITH ANTISERA			TYPES		REACTIONS WITH ANTISERA			TYPES	
Designation	%	Rh_0	Rh′	Rh″	Designation	%	Rh_0	Rh′	Rh″	Designation	%
W	15	—	—	—	Neg.	13	+	—	—	Rh_0	2
U	53.5	—	+	—	Rh′	1.5	+	+	—	Rh_1	52
V	16.5	—	—	+	Rh″	0.5	+	—	+	Rh_2	16
UV	15	—	+	+	Rh′Rh″	...[2]	+	+	+	Rh_1Rh_2	15

[1] For nomenclature, see Wiener ('44).
[2] Extremely rare; not yet observed.

For convenience of reference, in table 4 are presented the reactions of bloods of the eight Rh types with the three agglutinins, standard anti-Rh_0, anti-Rh′, and anti-Rh″. The approximate distribution of the types among Whites in New York City is also given for comparison with our findings on Chinese.

The bloods of American Indians, like those of Chinese, give very few negative reactions with standard anti-Rh_0 serum, but they give

many more negative reactions with the anti-Rh′ serum than either the Chinese or the Whites. In this respect, Amerindians resemble Negroes. This apparent contradiction would be reconciled if the bloods of American Indians, negative with the anti-Rh′ serum, are found to give regularly or almost regularly positive reactions with anti-Rh″ serum. As was shown in the previous paper (Wiener, Belkin and Sonn, '44), Rh-positive bloods negative to the anti-Rh′ serum include two types, Rh_2 and Rh_o, of which the former predominates in Chinese and the latter in Negroes. Therefore, it is reasonable to assume that type Rh_2, rather than type Rh_o, should also predominate in American Indians. Unfortunately, however, bloods of American Indians were not available to test this assumption.

SUMMARY

Tests were carried out on 138 blood samples from presumably full-blooded Chinese for the blood groups, subgroups, M-N types, and Rh factors. With regard to the blood groups and subgroups, our data confirm the high frequency of gene *B* as compared with Whites. A new observation is that all group A and group AB individuals belong to subgroup A_1 and not to subgroup A_2. The distribution of the M-N types in our series of Chinese did not differ significantly from that of Whites. In the Rh tests, only two out of 138 individuals were found to belong to the Rh-negative type, one to type Rh_o, and six to type Rh_2. Of the remainder, the majority belonged to type Rh_1 and the balance to type Rh_1Rh_2. The anthropological significance of the findings is discussed.

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A METHOD FOR REPRODUCING AND RECORDING CONTOURS

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This laboratory has developed a method for the reproduction and ecording of contours which is simple and rapid. The technique was orked out in connection with a foot measurement study [1] and will be sed to reproduce contours of the foot for which, until the present intance, no simple means of measurement has been devised. It is believed hat the method will prove useful in many anthropometric studies since : can be used on living as well as on skeletal and cadaverous material.

In brief, the method consists in laying strips of softened malleable ental impression compound [2] along the desired contour. After hardenıg, which occurs in a few moments, the molds so formed are removed nd pencil tracings are made therefrom.

The impression compound is prepared and cut into strips as follows. 'he plates of the compound are placed in water at 55°C., which is the ptimum temperature for softening; the material may be left there inefinitely with no detrimental effects. A few moments after immersion ıe compound may be picked up and handled without discomfort. It ; worked with the hands into a flat homogeneous mass roughly ovoid ı shape. If the mass seems to be hardening, it may be returned to the 'ater bath and will immediately soften. From this point on the process ıust be done rapidly to accomplish cutting while the compound is still ɔft.

The flattened mass is placed on a warm, not hot, glass plate which has een moistened with warm water and is there rolled with a metal roller) the desired length and thickness. It is cut quickly with a sharp calpel, guided with a metal ruler, into strips about 1 cm. wide. For ur purpose strips of two lengths, 15 cm. and 30 cm., are found useful. hickness is maintained at 4 mm. to insure a mold firm enough to allow ressure of the pencil in tracing.

[1] A study of foot measurement for shoe sizing is now in progress under Miss Ruth O'Brien, ead, Division of Textiles and Clothing.

[2] The material used in this study is Kerr's Perfect Impression Compound manufactured by e Detroit Mfg. Co., Detroit, Michigan.

The glass plate on which the cutting is done must be just comfortabl warm to the touch. If it is too cool, the compound hardens before it ca be cut and if it is too hot the compound tends to liquefy or may stic to the plate. We have found that a glass plate mounted on a box con taining a 60-watt electric light bulb 15 cm. below the plate keeps th glass at a desirable temperature.

After the strips are cut they are allowed to harden and are laid aside They may be kept indefinitely and can be handled without distortio but care must be exercised to prevent breakage through brittleness.

When contour molds are to be made the strips are placed in a consta temperature water bath at 50°C. In a few moments they become sof but they retain their sharp edges. They may be kept for hours in th water bath if care is taken to prevent their touching each other, sinc they have a tendency to stick together and thus spoil the edges.

In this softened state they are lifted from the water bath and place along the line to be reproduced. For accuracy in following the lin desired, it has been found useful to mark the line on the subject with skin marking pencil. Hardening takes place in a few moments at roo temperature. Best results are obtained when the molds are allowe to remain in place for a few moments after hardening to prevent distortion on removal. As the strips are laid in place, they may be cu with a scissors or a scalpel. This is useful in the case of circular o other closed molds, which are made in two or more sections to permi removal and is also valuable as a means of indicating the point t which a tracing is to be made. While in place, the hardened molds ca be marked with a white pencil to indicate the edge to be traced o other landmark. Great care must be exercised in laying the strips i direct apposition to the line to be reproduced in order to avoid distortion of their edges. In removal of the molds distortion must b further guarded against since stretching is a frequent source of erro The molds are now ready for tracing.

Tracings from the same molds have been made at intervals of 5 an 10 minutes over a period of 5 hours with no evidence of shrinkag or distortion.

When the tracings are completed the molds and the scraps fro cutting can be replaced in water at 55°C. and rerolled into strips. Th material has been used over and over again in this laboratory an the limit of its usability has not been reached.

In foot measurement it may be desirable to record contours wit weight on the foot. To accomplish this an impression of the planta surface is made in a beeswax impression mixture on which molds ca

be made as accurately as on the foot itself. The following formula for the impression mixture is a modification of one for a facial putty reported by Clark ('43) and furnishes a material soft enough to yield an impression and firm enough to retain its shape.

1 part beeswax (in gm.)
1½ parts mineral oil (in cc.)
½ part resin (in gm.)
Cornstarch as needed

The beeswax and mineral oil are heated together until entirely liquefied. The resin is added and the mixture stirred over a slow fire until the resin is entirely dissolved. It is removed from the fire, some cornstarch added, and is stirred continuously until cold. The mass is then tossed on a board covered with cornstarch and is kneaded until no more cornstarch is taken up.

The mixture may be prevented from sticking by wetting the hands and the object to be impressed. It may be used indefinitely. It hardens slowly over a period of weeks, but may be softened by reheating until melted, with a small addition of mineral oil. A mixture of almost any desired softness may be obtained by varying the amount of mineral oil. Excellent impressions are being obtained under fine silk gauze, the use of which eliminates sticking.

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PHYLOGENY AND CLASSIFICATION OF HOMINIDS AND ANTHROPOIDS [1]

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The abundant discoveries of fossil men and anthropoids made in the ast 20 years raise in acute form a number of problems regarding the elationships, classification, and phylogeny of the numerous fossil Pri-nates now available for study and comparison. It was formerly the ustom, with few exceptions, to regard most of these fossils as "side ines" leading to dead ends and not in the direct line of descent to nodern man. But Verneau ('24) considered that Neanderthal man, before becoming extinct in Europe, had contributed his blood to some European descendants. He believes that the Negroids of Grimaldi show Neanderthal influence and that the Negro race was earlier in ts evolutionary development than the yellow or white race. Hrdlička ('27) regarded Neanderthal man as having been directly transformed nto modern man during the Ice Age in Europe. The Piltdown and Swanscombe skulls, however, represent modern types of man which are even older than Neanderthal. It now appears that different lines of descent can also be traced in localized geographic areas — a view emphasized by Sir Arthur Keith — and that some at least of these ines lead directly to living types of man. The relatively abundant material now available makes it not only possible but necessary to con-sider afresh the principles of evolution and classification involved.

As a first consideration, we may assume that, unless there is good evidence to the contrary, the biological methods and principles worked out by paleontologists and paleobotanists are equally applicable to man. This is important, because students of fossil man have sometimes neglected these principles, or even assumed that they do not apply to man and his relatives. It is the aim of the present paper to discuss some of these problems in relation to recent investigations in this field.

In his recent monumental work on Sinanthropus, which includes a summation and commentary on previous work, much of it his own, Weidenreich ('43) concludes that the present relatively abundant re-

[1] For the Festschrift to Dr. Otto Schlaginhaufen, Professor of Anthropology, Zürich, Switzerland, in honor of his sixty-fifth birthday.

mains of Sinanthropus, Pithecanthropus, and Neanderthal man prov that evolution took a continuous course from these prehominid type through Neanderthal to modern man. While this conclusion may no be acceptable to all anthropologists, it will appear to many that on thi point he has adopted the most reasonable view of the evidence, bu LeGros Clark ('40 b) points out that late Mousterian man apparentl became more specialized and aberrant. From the prehominids t Neanderthal man seems an inevitable line of descent, at least so far a skull characters are concerned.

In recent years there has been an increasing tendency to recogniz the probability of intercrossing between Neanderthal or Palaeoan thropic man and men of the modern type. The fact that men of palaeo anthropic type, formerly known only from Europe (Gibraltar, Jersey and Malta to Central Europe), have since been found as far afield a Palestine and Java,— Homo soloensis being, however, according t Weidenreich, more primitive than Neanderthal man and nearer t Sinanthropus [2] — strengthens this series as a line of evolutionary de scent.

It is true that McCown and Keith ('39) interpret the remarkabl range of variation they found in the Mount Carmel skeletons as indi cating a people "in the throes of evolutionary change," i.e., tha they represent a population showing wide variation and incipien species formation by differentiation. But the Tabūn type of Moun Carmel resembled Neanderthal man, and the Schūl type the Cro-Magnon sort of recent man. If the type of skull found in modern man was al ready contemporaneous with or even older than that of Neanderthal as one must conclude from the evidence of Swanscombe, Galley Hil and Piltdown man in England, then it seems more reasonable to draw the conclusion that the Mount Carmel skeletons represent a hybrid population in which crossing had taken place between the Palaeoan thropic and Neanthropic species of man.

Various writers (e. g., LeGros Clark, '37, '40) and Zuckerman ('40) have pointed out that the genera Sinanthropus and Pithecanthropus are so nearly related that they should be merged into one genus. Since Pithecanthropus erectus was discovered many years ago by Dubois, Sinanthropus pekinensis now becomes Pithecanthropus pekinensis, according to the laws of biological nomenclature. We thus have clearly emerging three successive evolutionary grades, and from a biological point of view it is equally obvious that these must be classified as three genera. The oldest at the beginning of the Pleistocene is Pithe-

[2] In fact, H. soloensis appears to be essentially an enlarged Pithecanthropus form.

anthropus with two known species, one in Java and one in North 'hina; the next is Palaeoanthropus or Neanderthal man, of Palaeothic age, sometimes named (inadequately) Homo primigenius. He 'ill be considered again below. The third is modern man, of the genus Iomo proper.

Weidenreich regards Peking man and the ape-man of Java as merely ifferent races of one species. Although they are more or less contemoraneous, their exact contemporaneity cannot at present be estabshed. Sinanthropus made and used implements of Chelleo-Acheulian vpe, and according to Brodrick ('42) the cave deposits in which he s found probably correspond geologically with the Günz-Mindel or first nterglacial period in Europe. He probably migrated from Southern sia along with the water buffalo. Ostriches survived in North China 'ith Sinanthropus over 300,000 years ago, the previous fauna of 'hina having been much like that of Africa today, with numerous ntelopes, deer, ostriches, and elephants. From the numerous bones f mammals accompanying Pithecanthropus erectus, his age is either ate Pliocene or early Pleistocene, so the two species cannot differ reatly in age.

The distinctions between the skulls of P. pekinensis and P. erectus ould certainly be regarded as having at least the value of specific diferences if we were dealing with fossil monkeys and not men. They ay be roughly summarized as follows (Koenigswald and Weidenreich, '39): 1. The supraorbital torus in the skull of pekinensis s not only larger than that of erectus, but behind it is a continuous roove or sulcus not present in erectus. Clark ('37) suggested that he differences in the supraorbital region may be due to the relative evelopment of the air sinuses, but in Peking man with the larger orus the air spaces prove to be small or wanting. 2. The frontal egion is markedly higher than that of erectus and without the eculiar median bulge of the latter. 3. In erectus there is a broad iastema in the jaw between the upper canines and the lateral inisors — a condition not present in pekinensis. 4. The molars of rectus are larger than those of pekinensis, but the lower incisors nd lower canines are smaller. The canines also lack the cingulum resent in pekinensis. 5. The femur of pekinensis shows platymeria, hile those of erectus, if they belong with the skulls, do not. Later, Veidenreich ('43) finds that the P. erectus cranium has thicker walls twice the thickness of cranial bones in modern man), and a smaller ranial capacity (870 cc., as against 1075 cc. in pekinensis). They lso show neither Inca bones nor exostoses. Sinanthropus is thus more

primitive than P. erectus in some features, but more advanced in others. Skull IV from the Java site may not belong to Pithecanthropus as it has a sagittal crest and a larger maxilla which may relate it to Gigantopithecus.

Pithecanthropus erectus and P. pekinensis agree in having a torus occipitalis in extreme form, and Weidenreich ('40) shows the various stages of its reduction in later men. At the Neanderthal level it has undergone tripartition. In the Steinheim and Swanscombe skulls there is a tendency for it to merge into the occipital plane, but the median portion continues to exist. He points out that the Tasmanian skull has a primitive prehominid torus occipitalis, although otherwise of modern type, while in Ngandong skull VI (Palaeoanthropus soloensis) the sulcus supratoralis has disappeared and is partly replaced by a fossa, as in later men. The unequal rate of loss of different primitive skull characters is also well shown by the Steinheim skull, which has the torus occipitalis region reduced as in modern man, but the supraorbital torus heavy as in the prehominids and Neanderthal man. It therefore appears that these were separately inherited.

In their classic account of the Mount Carmel population, McCown and Keith ('39) point out the need for a revision of the nomenclature of Neanderthal man and adopt for him the generic name Palaeoanthropus of Bonarelli. They thus recognize:

1. Palaeoanthropus heidelbergensis, the primitive heavy jaw with modern teeth.
2. P. ehringsdorfensis, the Ehringsdorf skull.
3. P. neanderthalensis, the skulls of Düsseldorf and La Chapelle aux Saints.
4. P. krapinensis from Krapina (Croatia).
5. P. palestinensis, the twelve Mount Carmel and Galilee skeletons.

To these species may be added, as probably falling within the genus in the wider sense:

6. P. rhodesiensis, the Rhodesian skull, and
7. P. soloensis from Java, sometimes called Javanthropus.

Africanthropus njarasensis, though fragmentary, is regarded by Weinert as belonging with Pithecanthropus and Sinanthropus, but Weidenreich places it with the Rhodesian and Florisbad skulls. Forms at present little known, such as Meganthropus palaeojavanicus and Gigantopithecus may have their status altered as they become better known. The name Homo modjokertensis has been used for another Java skull which is now clearly recognized as a baby of Pithecanthropus erectus. That different names should be attached to different stages of

development of a species or even to different bones of an individual until they are known to belong together is not surprising. In paleobotany, one species of Pteridosperm, Lyginopteris oldhamia, had seven generic and seven specific names attached to its various parts, — roots, stems, leaves, etc., — until they were finally found, through attachments, to belong to the same species.

The occurrence of local evolution, or lines of descent of human types within one continent, is a principle which has been clearly recognized by Keith ('31) and the evidence for it is constantly accumulating. Thus Pithecanthropus erectus → P. soloensis → Homo wadjakensis → Talgai skull → modern Australian aborigines, appears to be a line of evolution beginning in Java and ending with the Australian type of modern man, in harmony with the view that the Australoid type developed in Southern Asia and is still represented by various jungle tribes in India and the Veddas in Ceylon. Similarly, in South Africa, from the work of Dart ('40) and others, we have the probable series, or lineage → Rhodesian man → Florisbad → Boskop → Strandlooper → modern Bushmen. Weidenreich is evidently in agreement with this point of view when he says that the conception of one centre of human evolution is incorrect. He has elsewhere ('39 a) concluded that regional or racial differentiation is as old as human evolution itself.

In China, Weidenreich ('43) finds as many as twelve features in the crania, teeth, and limb bones of Sinanthropus which occur with relatively high frequency in Mongoloids. While he seems to have rather exaggerated these similiarities, they include such points as a mid-sagittal crest, the Inca bone, features of the nasal bridge, cheek region and zygoma, shovel-shaped upper lateral incisors, exostoses of the maxilla, mandible and ear, high platymerism of the femur and a straight deltoid tuberosity of the humerus. Elsewhere ('39 b) he cites (1) the torus mandibularis, (2) shovel-shaped central and lateral upper incisors, (3) the os epactale (Inca bone) and (4) a very pronounced sagittal crest, as Mongoloid characters found in 70–100% of Sinanthropus. It appears, at any rate, that certain morphological features of the skeleton of Sinanthropus have been transmitted with higher frequency to the modern Mongoloids of Eastern Asia and the American Indians. Some of them at least may be determined by single genes.

Weidenreich ('43) makes the surprisingly näive suggestion that if Sinanthropus → Palaeoanthropus → Homo is a continuous evolutionary line of descent, therefore all forms involved must belong to one species.

He says (p. 256), "The hominids have formed — and still form — one family or, in a strictly taxonomic sense, *one*[3] species," and again (p. 259), "The hominids represent always but one species." This dogma of one human species stems from Linnaeus in the eighteenth century, but it can not be taken seriously in the light of modern knowledge. In every group of organisms except man, the treatment accorded by Linnaeus has been more or less profoundly modified. Weidenreich should consult the palaeontologists for enlightenment on this subject. A little thought will make it clear that every living species must have been derived by continuous breeding from a different ancestral one; and as we know now, especially in plants, crosses between two species may also be involved in producing a third. It is possible that even certain new phyla of plants may have been initiated in this way. The evidence of the important part played by crossing in the long line of ancestry of man is no longer negligible. It appears to me that throughout human evolution isolation in some areas and crossing in others have both played their part. The upper cave at Choukoutien contained skulls of a "family" (culturally Upper Palaeolithic), one regarded as pre-Mongoloid, one Eskimoid, and one Melanesoid. This would be a wide range of types to meet together even under modern globe-trotting conditions. To call them generalized types only partly solves the difficulty.

Although much has been written recently on speciation and taxonomy, Bather's ('27) treatment of the subject from a paleontological point of view deals fundamentally with the problems in a way that has not been surpassed. It is contained in his presidential address to the Geological Society of London, but is less known than its erudition deserves. His unrivalled knowledge of fossil echinoderms forms an ample basis for conclusions. Using the old analogy of a tree and its branches, he points out that the twigs on different branches will belong to different genera, while the twigs on one branch will be species of the same genus. In tracing back a single line of descent, "To delimit the species a horizontal line must be drawn across the lineage at a level arbitrarily fixed," but in practice these lines are generally determined for us by gaps in the series of strata.

As a lineage is traced back, it joins other lineages. How many of these are to be brought into the genus? This depends on the number of final twigs (species) enclosed between vertical divisions (branches) or on the level at which the horizontal line is drawn. "Every species (in fossil Echinoderms) had an ancestor and every species . . . . .

[3] His italics.

ıight have had a descendant.'' Bather complains (justly) of the ten-
.ency to found a new genus wherever there is a slight discontinuity
ı the series of forms, thus making almost as many genera as species
nd so defeating the object of classification, which is to show rela-
ionships as well as differences.

Another pregnant statement, the truth of which is still insufficiently
ecognized by taxonomists and describers of fossil species, is that ''Most
ossil genera represent grades of organization rather than lines of
escent.'' In parallel evolution, many species will thus have given
ise to a new species belonging in a different genus. Bather recognized
he frequent development of parallel lineages and cites, among many
xamples, Abel's treatment of the Cervidae. Abel traced distinct lines
f descent through four successive genera (grades) in Miocene and
'liocene times. Bather also showed that a cross-section of a lineage
eveals different rates of evolutionary acceleration or retardation of
arious characters. He recognized that lineages may interbreed, form-
ıg a plexus; and he drew the conclusion with which all will not agree,
ıat gradual (quantitative) characters are not the same in behavior
s the Mendelian factors which differentiate elementary species or
ordanons. He further maintains that ''The whole of our system . . .
; riddled through and through with polyphyly and convergence.'' These
eferences to his main conclusions give an inadequate expression of
ıe broad philosophical foundation on which they were based.

As the one who described the first case of parallel mutation in 1912,
nd afterwards (Gates, '20) pointed out numerous similar cases in
nimals and plants, I may be permitted brief reference to this aspect
f evolution in man. Although Keith recognizes parallelisms in the
volution of man, probably LeGros Clark has most strongly emphas-
ed this aspect. In various papers (Clark, '34, '36, '40 b) he has
ointed out numerous parallel developments, (1) among the Lemurs,
2) between the Old World and New World monkeys, (3) between
[ominidae and anthropoid apes in some of their anatomical features.
'e says this ''evidence leads inevitably to the conclusion that evo-
ıtionary parallelism has been a much more common phenomenon
ıan is usually recognized, and it must obviously be taken into ac-
ount in any philosophical study of evolutionary principles.'' Evolution
not ''merely a matter of action and reaction between the physico-
ıemical factors of the environment and those of a passive or at least
neutral and completely plastic organism.'' This view is not necessarily
ontrary to the mutation theory, although long parallel series ob-
iously require a special explanation. The principle can be over-em-
hasized, as Hooton ('35) has pointed out, but it cannot be overlooked

in the consideration of man's relations with the anthropoids. Modern monographs on various groups of animals and plants appear to show it abundantly as an evolutionary factor. One of its implications is that the amount of resemblance between two species is not always an accurate measure of their degree of relationship.

Local evolution (which implies isolation) is recognized by Weidenreich ('43) in the probable line of development from Rhodesian man to modern South African races, and also in the continuous line from Pithecanthropus erectus through Palaeoanthropus soloensis to fossil and modern Australoid types in Southern Asia and Australia. He also clearly adopts the conception of evolutionary levels when he says ('39 p. 14), "The general resemblances between the Australian aborigines of today and the Upper Paleolithic European would then be a consequence of both representing a similar stage of evolution rather than that of an early immigration of the Paleolithic European into the Australian continent." [4] Having progressed so far, he makes the amazing statement ('43, p. 215) that "Neither space nor time can play any rôle in the zoological classification of human types." This is apparently an effort to dispose of Eoanthropus and the Swanscombe skull, which by no means fit into his scheme. These finds in England, at least as old as Neanderthal man on the Continent, clearly fall into the genus Homo and therefore require a broadening of his evolutionary scheme. They can only be reconciled with it by assuming that human evolution has proceeded at different rates, a primitive type of man surviving in Central Europe after the essentially modern type had appeared in the West. This is in harmony with well known paleontological principles, and also with the principle, emphasized by Hooton ('25 a) that the change of particular characters in man has proceeded at different rates. A striking example of it among the anthropoids is found in the Australopithecinae of Dart and Broom. This group of late surviving anthropoids had the erect gait and essentially the dentition of the Hominidae.

The evidence of the Committee [5] which investigated the Swanscombe parietal and occipital shows that stratigraphically it is one of the best authenticated of all human remains, and geologically the evidence of the age of the gravels in which they were found is very complete. The Committee were in complete agreement that there can be no doubt that the Swanscombe skull is an indigenous fossil of the gravels of

[4] The recent finding of an Australoid skull near Melbourne (see Zeuner, '44) said to belong to the Riss-Würm Interglacial supports the view that the genus Homo evolved independently in Australia and in Western Europe.

[5] J. Roy. Anthrop. Inst., vol. 68, pp. 17–98, 1938.

the 100-foot terrace of the Thames. This adds significance to the Galley Hill skull, which was also found in the 100-foot terrace of the Thames in 1888, and has often been regarded as of doubtful provenance, since it has no excessive development of brow-ridges and the chin and teeth are not extraordinary. The Swanscombe skull is the first fully authenticated human bone from a known Acheulian horizon. An interval of 8 years separated the finding of the parietal and occipital, but they were in the same seam of gravel 24 feet below the surface and their sutures fit together perfectly. This zone was full of Acheulian implements, and in the layer below they were Clactonian. Swanscombe man thus adds to the significance not only of the Galley Hill skull but also of Piltdown, the stratigraphic age of which appears to be equally well established.

Keith ('39), in a restudy of the Piltdown skull, has made various comparisons with the Swanscombe specimen. In both, the skull bones are very thick, in Piltdown 9–11 mm., Swanscombe 4.6–7 mm. The latter is more like modern man and the former shows greater asymmetry of brain than in any modern race. While Weidenreich discards the Piltdown jaw as that of an orang (not a chimpanzee), Keith after a most exhaustive analysis is more firmly convinced than before that the skull and jaw belong to the same head. The measurements found are as follows:

	LENGTH	BREADTH	C. I.	HEIGHT	CRANIAL CAPACITY
Swanscombe	185 mm.	144 mm.	77.8	110 mm.	ca. 1350 cc.
Piltdown	194 mm.	150 mm.	77.3	110 mm.	ca. 1358 cc.

He also points out that the London skull, found in deep excavations, and the Bury St. Edmunds cranial fragment probably belong to the same period and race as the Swanscombe skull, all being from Southern England. Taken together, their significance can hardly be shaken by discarding the paleontological principles associated with time and space. They are found at the opposite extreme of Eurasia from Peking man and might therefore be expected to show the maximum amount of difference, since space and time are factors which have to be taken into account.

That the chronological principle is violated in human evolution is admitted by Weidenreich himself, who cites the Steinheim skull as belonging to the interglacial Riss I / Riss II, much older than the classic Neanderthal type, yet morphologically much more modern as regards the temporal, occipital, and other features.

Having concluded that the three main stages of human evolution should be regarded, on paleontological principles, as three distinct genera or grades, each containing two or more species, and having

traced certain lineages through long periods in South Africa and S. Asia, how shall we deal with modern man? If we are to be consistent there is only one conclusion.

Some years ago (Gates, '26) I wrote, "If these colour-types (of mankind) could be viewed from a quite impersonal biological point of view, it is probable that they would be recognized as differing in ways that are analogous to the differences between many animal species." Later (Gates, '37), I said, "We very much need a considered classification of human races, living and extinct, based upon criteria similar to those which have been applied to the classification of mammals, and especially the Primates, into genera, species, subspecies, geographic races and varieties." The last three categories may be taken as equivalent.

After pointing out that students of the geographic distribution of mammals such as mice do not find the subspecies homogeneous throughout their range, I said, "It appears to me that we are justified in regarding mongoloid, australoid, caucasoid, and negroid types of man as representing separate species, each with various geographical races more or less clearly defined. . . . The justification for this view will depend upon how long these four specific types have been evolving in separate geographic areas more or less isolated from each other." I would now add the Bushmen as a fifth species of Homo who, all are agreed, are descended from an isolated line of evolution which probably goes back to Rhodesian man. The isolation was not always complete. At an early period, Mongoloid characters came in from some extra-African source. Smaller accretions of blood from other sources may also have been incorporated at intervals, but not enough to disturb seriously a line of descent in relative isolation on the African continent, ending in the Bushmen and probably also in the Ituri pygmies of Central African forests. The Hottentots have obviously shared in part the same descent but they are taller, more dolichocephalic and more negroid, which can be accounted for by crossing with the Bantu or other negro stock. The pockets of Negritos stretched across Central Africa and Southern Asia as far as the Philippines appear to be remnants of an early stock.

We are thus lead to recognize [6]:

1. Homo australicus, the most primitive surviving species of man, with an ancestry stretching back to Pithecanthropus.

[6] von Eickstedt ('37) and Peters ('37) have assembled at length the various systems of nomenclature which have been applied to modern man.

2. H. capensis, the Bushman type, with long evolution in relative isolation in S. Africa.

3. H. africanus, the Negroid type, already being differentiated in the Pleistocene, as shown by the Grimaldi skeleton.

4. H. mongoloideus, the Mongoloid type, some of whose anatomical peculiarities were already present in Sinanthropus, although his specific characters have developed since.

5. H. caucasicus, the white type, represented by the subspecies (a) the Mediterranean race, oldest in age and most southerly in distribution, (b) the Nordic race, derived from it mainly through loss of pigmentation, (c) the Alpine race, embodying the brachycephalic mutation and other features.

Other subraces, such as the Dinaric and East Baltic, evidently involve crossing, as suggested by Hooton ('31) and others. The whole matter of crossing in relation to race is much too extensive to be entered into here. I hope to deal with it elsewhere. Hooton ('25 b) has given good reason for believing that the Cro-Magnon type, the first modern man recognized on the European continent, is really the product of a cross between a dolichocephalic stock of the Galley Hill-Swanscombe type and a brachycephalic strain (Ofnet). This would account for the combination of long narrow head with broad face found in Cro-Magnon — a type which he shows can also arise from crosses among modern families.

Dart ('40) similarly postulates that the Bantu type in Africa arose from Bushman × Negro, with infiltration at intervals of Caucasian blood from the Nile valley. He regards the Bushman as a pygmaeopaedomorphic and the Boskop skeletons as the corresponding gigantopaedomorphic type. Half the modern Bushmen show Boskop stigmata. The Ituri Pygmies are regarded as differing from the Bushmen only in having more Bush and less Boskop ancestry (and probably also more recent Negro blood). Many other instances of racial crossing to produce new types (secondary races) might be adduced. Modern European populations are so intermingled through processes which have been going on throughout history and prehistory that any geographic boundaries between Nordic, Alpine and Mediterranean have largely ceased to exist. No one expects to find a relatively pure race except in local pockets, still relatively undisturbed. Notwithstanding this mingling of types in modern populations, it is clear that when populations were sparse and methods of communication non-existent a much greater isolation and relative purity of type was often preserved over long periods. Then new contacts might modify more or less markedly

both races taking part in it, according to the relative frequency of the two ingredients.

This greater isolation is shown by the gorillas, and as a result of it Schultz ('34) gives good reasons for regarding the mountain and lowland gorillas of West Africa as separate species. He lists 25 differences, including longer trunk, longer palate, shorter arms, relatively shorter and broader hands, and shorter toes with more extensive webs. Probably in his prehominid stage of evolution, man was little if any more migratory than the gorilla, with the result that geographic isolation of types was almost equally marked.

SUMMARY

1. In a discussion of the paleontological and biological principles involved in the evolution of hominids and anthropoids, it is pointed out that a self-consistent system of classification and nomenclature must emerge from the study of the numerous fossil forms of various ages now known from many parts of the world.

2. According to paleontological principles, the three levels of human evolution represented by (a) the prehominids, (b) palaeoanthropic man, (c) neanthropic man, fall into three distinct genera — Pithecanthropus, Palaeoanthropus, and Homo. In accordance with Weidenreich, this represents a continuous line of evolution from Pithecanthropus and Sinanthropus through Neanderthal to the modern type of man.

3. As evolutionary factors in man and anthropoids have to be considered not only the fundamental types of change which presumably depend upon larger and smaller mutations, but also parallel mutations, longer parallel lineages, and crossing between lineages.

4. The importance of local evolution is shown in such lineages as (a) that from Pithecanthropus to the modern Australoid type in Southern Asia and Australia, (b) that from Rhodesian man to the modern Bushmen in South Africa.

5. The differences between Pithecanthropus erectus in Java and Pithecanthropus pekinensis in China are such as would lead to their recognition as separate species if they belonged to other groups of mammals. There is no certainty that they are even contemporaneous.

6. That it is impossible to ignore time and space in the evolution of hominid types, is shown not only by Piltdown, Swanscombe and other types of relatively modern man in ancient strata. The different rates at which particular primitive skull characters are lost is well shown by such skulls as that of Steinheim and the modern Tasmanian. It is also shown in comparisons of Pithecanthropus and Sinanthropus.

7. There is considerable evidence that single teeth and single bones f the skull such as the Inca bone, are controlled by single genes and etermined as units.

8. Isolation and crossing have both played their part throughout uman evolution, at different times and in different areas. The Mount 'armel population appear to be hybrids between Neanderthal and a iodern type perhaps descended from the time of Swanscombe man. 'ro-Magnon man himself appears to be a hybrid combination.

9. The living "races" of man are not contemporaneous divergents rom a common stock, but are of different ages, the Australoids being he oldest, then the Bushmen, followed probably by Negroids, Mongoiids and Caucasoids in that order.

10. Any consistent scheme of classification on a sound paleontolo-ical and biological basis should recognize these five so-called primary aces of man as species.

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PHYSICAL ANTHROPOLOGY IN THE ARMY AIR FORCES[1]

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THREE FIGURES

I. INTRODUCTION

The military utility of physical anthropology has long been recognized; longer, indeed, than the study of man has existed as a formal science. Armies and navies have always been concerned with the physique of their men, from several standpoints — among them medicine (in relation to health and stamina), logistics (design of equipment, size and nature of rations, speed of march), administration (classification and identification), and even esthetics (as in the selection of companies by stature for parade drill, and in the many historic Guards regiments of extremely tall men). Measurement of dimensions deemed important has devolved upon the military surgeon and has become an established part of routine medical examinations. Data from such examinations have been useful to the soldier in establishing physical standards for recruits and to the anthropologist in constituting a valuable source of information on the population of a country at a given time.

In the United States, Davenport and Love's ('21) monumental Army Anthropology sketches the brief history of military anthropology in this country, indicates possible applications of anthropology to warfare, and presents a wealth of data of great scientific and military value. It is pointed out that the study of man in the mass, military as well as civilian, is properly the function of the specially trained anthropologist. "One of the lessons taught by the experience of raising an Army in 1917–1918 is that, at the outset, there should be appointed among the officers of the Medical Department, a broadly trained anthropologist to whom should be assigned the following tasks: (1) collaboration in . . . schedules of physical examinations; (2) measurements and observations on recruits; (3) identification data; (4) . . . racial classification." (p. 48). The authors might have added possibly the most important task

[1] The work described in this paper is a joint project of Captain Randall, Lieutenant Damon, Lieutenant Robert S. Benton, and Dr. Alice M. Brues.

of all, as found by current experience in the Army Air Forces: (5) the translation of anthropometric data into practical, military terms, a task which may at times require the anthropologist to become an engineer or designer himself.

Army Anthropology appeared too late for practical application in the First World War. Since that time, its data have been used to establish physical standards for recruits, but inasmuch as the population has changed considerably during the intervening 25 years, its applicability for this or other purposes to soldiers in the present War is limited. An Army-wide anthropological survey in the Second World War is thus highly desirable scientifically and practically; to understand our present military population and to devise and procure equipment for the soldiers who are to use it.

The present paper will describe briefly and in general terms the current anthropological program of the United States Army Air Forces, conducted at the Aero Medical Laboratory, AAF Materiel Command, Wright Field, Dayton, Ohio; under the direction of Colonel Otis O. Benson, Jr., through April 1943 and of Lieutenant Colonel W. Randolph Lovelace, II, from that time to the present (May, '44). Certain aspects of anthropological interest may be discussed in more detail in the future. Inasmuch as the population involved is highly selected and the problems special, the data are hardly applicable to the Army as a whole; indeed, the whole Army Air Forces project can best be regarded as a component part of an Army-wide study (of which a similar project by the Armored Command, Army Ground Forces, is another). However, as the pioneer effort in this War, and possibly the most intensive application of physical anthropology to military needs that has yet been made, the experience and general conclusions reached thus far may be of value not only for further military problems, but for the broader field of Human Engineering, a branch of physical anthropology as yet relatively undeveloped — despite sporadic anthropometric hat- and seat-sizing — but of great potential importance. War is a notorious accelerator of the practical trends in a science; and it is entirely possible that the physical anthropologist of the future may have a direct influence on the daily lives of us all, as he has at present on the occupations and equipment of thousands in the armed forces.

The main point to bear in mind in evaluating the following discussion is that the work is intensely practical. Military necessity has dictated the existence of the project itself, the selection of subjects and measurements, and the treatment and applications of the data. A host of fascinating anthropological vistas have been glimpsed — the relation

of physique to various military abilities and to available medical, psychological, and sociological data; racial and regional comparisons among these young men, outstanding representatives of their respective groups; comparisons with other large groups of young men, in colleges, in the last War, or in our current armed forces — but all have been eschewed for the present. It is hoped that this rich harvest will one day be gleaned.

II. DEVELOPMENT OF THE PROJECT

A. Historical

The need for exact knowledge of human variations and dimensions is even greater in aviation than in the older military and naval arms, because of the paramount importance of space. Flyers must be fitted into spaces which are initially kept to a structural minimum by aircraft designers, and are thereafter subject to continual encroachment for tactical purposes; while the extremes of temperature and pressure encountered make the fit of personal equipment (such as oxygen masks and flying clothing) a matter of survival itself. The Army Air Forces, with a highly selected population of flyers, has had no body of data comparable to that available in Army Anthropology to the Army Ground and Service Forces. As a result, it became evident during the great expansion of the Army Air Forces beginning in 1940, that shortages in some sizes of flying clothing and surpluses in others were occurring; certain escape hatches were too small for safety; and, most serious of all, gun-turrets were imposing a severe limitation on the size — and, consequently, on the number — of gunners able to operate them.

In the summer of 1940, Colonel (then Captain) Otis O. Benson, Jr., a Flight Surgeon in the Regular Army, was assigned to the Harvard Fatigue Laboratory for intensive research on the physiological problems of high altitude flying. Aware of the increasing importance of human sizing problems in aviation medicine and engineering, Colonel Benson realized, in discussions with Dr. Earnest A. Hooton, Professor of Anthropology at Harvard, that physical anthropology had the techniques of measurement and analysis appropriate to such problems. A tentative anthropometric project was agreed on. As Chief of the Aero Medical Laboratory (then the Aero Medical Research Unit) of the Army Air Forces, Colonel Benson was strategically situated at Wright Field, the center of experimental and developmental work in AAF aircraft and associated equipment, and hence could coördinate anthropological research at all stages with the Aircraft, Armament, and Equipment Laboratories. Thus, these Laboratories could pose the problems: How

much clearance does the average (or the extreme) pilot or gunner ne above his head or across his shoulders? Where should a range pedal a ball turret be located? How many sizes of oxygen masks, clothin or parachute harnesses are necessary, and what proportion of ea size should be produced? Then the Aero Medical Laboratory cou select technics and subjects to answer such questions, and could tran late its anthropometric data into the appropriate engineering term At the same time, the close association of the Aero Medical Laborato with the Office of the Air Surgeon, at AAF Headquarters in Washin ton, would facilitate the use of anthropology in the selection of pe sonnel.

Turrets constituted the major problem at the time, as already me tioned. Accordingly, in February 1941, Colonel Benson invited D Hooton to Wright Field to inspect American and British turret mode and to draw up a list of body measurements important in turret desig Dr. Hooton's findings emphasized the advisability of a general surve of AAF flyers, both cadets and gunners, to determine what proportio of flyers could use existing equipment; what size criteria would desirable in their selection; and how existing equipment might be mod fied and future materiel designed to accommodate the largest possib number of flyers.

Preliminary plans for the survey were under way when the Unite States entered the war in December 1941. After a brief period of u certainty, it was decided by higher military authority that if the surve would have been useful in peacetime, it was even more necessary in wa Permission was granted by the Air Surgeon, and the survey proceede at an accelerated pace.

B. Basic body size survey

1. Selection of measurements. The more problems to which an a thropometric survey could be applied, the greater its value. And sinc there were in fact a variety of problems involving human dimension it was decided to include general measurements and observations a well as those required for the turret study. The alternatives would b to make a separate survey as each type of problem occurred, or to tak at one time as many measurements as might conceivably be useful fo any problems. Neither of these alternative procedures was feasible i view of the urgent time element, the desirability of large numbers o subjects, the impossibility of foreseeing all the anthropological problem which might arise in the future (and some bizarre ones have arisen!

and the desire to interfere as little as possible with the subjects' training schedules. The decision to include general traits was sound scientifically as well as practically, since the basic measurements taken have been found to afford reasonable prediction of those subsequently required. Occasionally no good correlations can be found, and special measurements (such as height of calf muscle above ground, for foot-gear; or height above seat of the inferior angle of the scapula, for placing straps in canvas troop-seat backs) must be taken on a small sample selected to represent the larger series in age, height, and weight.

The Anthropological Survey Blank (figs. 1 and 2), thus contains measurements dictated by turret problems plus others chosen for general utility. The Blank was drawn up by Lieutenant Colonel (then Captain) A. P. Gagge, representing the Aero Medical Laboratory; and Drs. Hooton and Carl C. Seltzer of Harvard University. The indices and the data on the obverse of the Blank represent a combination of scientific interest, military utility, and an attempt to afford a physical basis for differential training of personnel. Thus, the sociological background data, so easy to obtain while the subject is waiting his turn, and so valuable in anthropological research, might be used as a check on the representativeness of the sample. Applicability of Air Forces data to other branches of the Armed Forces would be limited if significant racial, regional, or occupational differences appeared. Pigmentation and the rough index of skin sensitivity afforded by the "vascularity" test (estimation of reaction to a standardization scratch on the chest) have already found application in estimating susceptibility to sunburn and the need for goggle protection — both requests received by Dr. Hooton from the Office of the Quartermaster General. The indices have not been used so far, but somatotypes have and the latter deserve additional comment.

As anthropologists are becoming increasingly aware, the constitutional analysis of Dr. W. H. Sheldon ('40, '42) affords an excellent means of studying the correlation of physique with medical, psychological, and sociological phenomena. Concise, quantitative, and based on objective anthropometry, "somatotype" (body build, in terms of three primary components); "dysplasia" (disharmony between separate regions of the body, in regard to proportions of the three primary components); and "gynandromorphy" (degree of femininity in the male physique) have valuable potentialities for the classification and differential selection of personnel. Some of these are being explored and will be mentioned in Section III-A, below.

In compiling the data sheet, time required for completion was major consideration. Only after assurance that a trained observer co fill one in 12 minutes was it approved.

2. Organization of survey. Once the data sheet had been drawn the survey was organized into observation and analysis, to proce concurrently. Two teams of two observers each took the measureme and mailed them back to Harvard at the end of each day; each obser in a separate envelope, to minimize the effect of a possible loss in tran

Serial No. U. S. ARMY AIR CORPS — MATERIEL DIVISION — ANTHROPOLOGICAL SURVEY

NAME.... (last) (first) (middle) Observer .... Date....

Col. Punch

1 ..... LOCATION.....

2 ..... MILITARY UNIT.....

3 ..... RANK: private[12] | non-com.[11] | officer[10] |

..... INDUCTION BASIS: selectee[1] | volunteer[2] | reserve[3] |

4 ..... AGE..... (last birthday)

5 ..... BIRTHPLACE — SUBJECT:..... (State, if U. S. A.; or country, if foreign)

6 ..... BIRTHPLACE — FATHER:..... (State, if U. S. A.; or country, if foreign)

7 ..... BIRTHPLACE — MOTHER:..... (State, if U. S. A.; or country, if foreign)

8 ..... NATIONAL EXTRACTION..... (Two principal strains)

9 ..... RELIGIOUS AFFILIATION (Familial): | Protestant[12] | Catholic[11] | Jewish[10] | Other[1] |

..... EDUCATION (Highest Schooling): | illiterate[2] | read and write[3] | grade[4] | high[5] | special training (tech., bus., etc.)[6] | college[7] | prof.[8] |

10 ..... OCCUPATION (principal).....

11 ..... MARITAL STATUS: single[12] | married[11] | divorced or separated[10] | widower[1] |

..... RACE: White[2] | Negroid[3] | Mongoloid[4] | Other[6] | .....

Col. Punch

12 ..... HAIR COLOR: black[12] | dk. brown[11] | med. brown[10] | red brown | gold brown[2] | ash brown[3] | golden[4] | ash[5] | red[6] |

13 ..... HAIR FORM: straight[12] | low wave[11] | deep wave[10] | curly[1] | frizzly or woolly[2] |

14 ..... EYE COLOR: pure dark (dk. or lt. brown)[12] | pure light (gray, blue, gray-blue)[11] | mixed light[10] | mixed even[1] | mixed dark[2] |

15 ..... SKIN COLOR: pale[12] | med. pink[11] | florid or ruddy[10] | brunet[1] | swarthy[2] | yellow brown[3] | dk. brown[4] | black[5] |

16 ..... VASCULARITY: (scratch on chest) | abs.[12] | subm.[11] | med.[10] | pron.[1] |

SOMATOTYPE:

17 ..... ENDOMORPHY 1–2–3–4–5–6–7

18 ..... MESOMORPHY 1–2–3–4–5–6–7

19 ..... ECTOMORPHY 1–2–3–4–5–6–7

20 ..... ANDROGYNY: 1–2–3–4–5–6–7

21 ..... DYSPLASIA: 1–2–3–4–5–6–7

22 ..... MUSCLE TONUS: sm. (totally relaxed)[12]
sm. (soft)[11]
+ (med.)[10]
++ (tense)[1]

Fig. 1 Basic body size survey blank.

— actually, none occurred. At the Peabody Museum, the data we coded and punched on International Business Machine cards as receive awaiting completion of the series. Trends could thus be observed, a incipient deviations in technique or interpretation arrested. For urge problems, a tabulation of the most important dimensions for turre was prepared for the first thousand subjects and sent to Wright Fie before the series was completed.

a. Participants. In addition to Colonel Benson and Lieutenant Color Gagge of the Aero Medical Laboratory; Dr. Hooton, Consultant, a

Dr. Seltzer, Assistant Consultant, of Harvard University; the observers were Albert Damon, Francis E. Randall, Judson T. Shaplin, and Ivar Skarland; and the statistical analysts were Dr. Alice M. Brues and Mrs. Agnes W. Gebhard. The measurements for the body size survey were taken during March and April 1942. Mr. Shaplin left the project in May; and in July, 2 months after the three remaining observers had returned to the Aero Medical Laboratory from the field, Mr. Skarland left. The authors have remained with the project as commissioned

	Col.	Punch	Decimal
Subject Standing			
WEIGHT	23		
STATURE	24		
SPAN — TOTAL	25		
ANTERIOR ARM REACH	26		
SPAN — AKIMBO	27		
BIACROMIAL	28		
BI-DELTOID	29		
CHEST BREADTH	30		
CHEST DEPTH	31		
ABDOMINAL DEPTH	32		
BI-ILIAC	33		
FOOT LENGTH	34		
FOOT BREADTH	35		
HEAD CIRCUM.	36		
CHEST CIRCUM. (rest)	37		
CALF CIRCUM. (left)	38		
Subject Sitting			
SITTING HEIGHT	39		
TRUNK HEIGHT	40		
BUTTOCK-KNEE	41		
PATELLA HEIGHT (from floor)	42		
BI-EPICONDYLAR (elbows)	43		
BI-TROCHANTERIC	44		
BI-EPICOND. FEMORAL (knees)	45		
SHOULDER-ELBOW HEIGHT	46		
SQUATTING DIAGONAL	47		
HEAD LENGTH	48		
HEAD BREADTH	49		
FACE BREADTH	50		
FACE LENGTH	51		

	Col	Punch	Decimal
NOSE LENGTH	52		
NOSE BREADTH	53		
HAND LENGTH	54		
HAND BREADTH	55		
Indices			
HEIGHT (in.)/$\sqrt{\text{WT. (lbs.)}}$	56		
SITTING HEIGHT/STATURE	57		
CHEST BREADTH/BIACROMIAL	58		
CALF/BIACROMIAL	59		
CHEST D./BIACROMIAL	60		
BI-ILIAC/BIAC.	61		
HEAD CIRC./CHEST CIRC.	62		
CHEST CIRC./STATURE	63		
CHEST D./CHEST BR.	64		
HEAD BR./HEAD L.	65		
FACE L./FACE BR.	66		
NOSE BR./NOSE L.	67		
	68		
	69		
	70		
	71		
	72		
	73		
	74		
	75		
	76		
	77		
	78		
	79		
	80		

Fig. 2 Basic body size survey blank (reverse).

officers. Subsequent additions to the project include Dr. Brues and Lieutenant Robert S. Benton, anthropologists; Sergeant Robert C. Koepnick and Miss Alice King, sculptors and technicians; and Pfc. James H. Thomas, plastics expert.

b. Training of observers. All four observers were students of Dr. Hooton and trained in Dr. Sheldon's system of analyzing body build. In addition to this initial similarity of training, 3 weeks were spent exclusively in standardizing techniques, so that when the observers entered the field, their procedures were thoroughly comparable.

c. Selection of subjects. In 1941 and 1942, there were three AAF stations through which all aviation cadets were sent after passing the physical examination for flying. These were Maxwell Field, Montgomery, Alabama; Kelly Field, San Antonio, Texas; and Santa Ana Air Base, Santa Ana, California. Aerial gunners were being trained at the Harlingen Army Gunnery School, Harlingen; Texas; Tyndall Field, Panama City, Florida; and Las Vegas Army Gunnery School, Las Vegas, Nevada. One team of two observers was sent to Maxwell and Tyndall Fields, and another to Kelly and Harlingen. Unfortunately, there were not enough observers to include the Western fields, Santa Ana and Las Vegas, of which the former especially draws men from the Pacific Coast. This omission (only about 2% of the entire survey are from the Pacific States) diminishes the representativeness of the sample and might change the observed distribution of traits significantly for the anthropologist, but probably not for the aviation engineer.

d. Number of subjects. At Kelly and Maxwell Fields, 2954 Aviation Cadets were measured; and at Tyndall and Harlingen, 584 gunners, the entire gunner population of these schools at the time. Detailed figures for this and the other major surveys to be described are presented in table 1.

C. Subsequent body size surveys

The general body size survey has always constituted the backbone of the project, but supplementary surveys have become necessary as new problems have involved special measurements or populations. For example:

1. Special problems — manikins, somatotypes, combat equipment. (a) In the construction of the manikins described in Section III-A, below, additional measurements were necessary, since those taken in the basic survey could not suffice for a three-dimensional, full-scale model of a flyer. The required measurements (such as ankle and crotch height, arm and leg circumferences, etc.) were accordingly taken on a small, selected sample of Aero Medical Laboratory personnel. (b) In connection with studies on the relation of physique to susceptibility to high-altitude "bends", 152 photographic reconnaissance pilots; 40-odd University of Cincinnati Medical School students; and 29 Aero Medical Laboratory subjects have been somatotyped. (c) Special combat equipment designed for pursuit pilots involves several special body circumferences. These have been taken, together with the routine stature and weight, on 164 pursuit pilots.

2. Clothing measurements on specialized aircrew. Experience in the clothing sizing program to be described in Section III-D, below, demonstrated a conclusive need for specific tailors' measurements (such as sleeve outseam, waist and seat circumferences, and leg inseam), taken according to standard trade practice. Trade formulas for predicting these dimensions from height, weight, and chest circumference were checked, and when modified as required to fit the AAFseries, gave workable but still not entirely satisfactory results. The need for a separate

TABLE 1

Major surveys of the Army Air Forces anthropological projects

Body Size Surveys	
General	
Cadets	2954
Gunners	584
Total	3538
Clothing	
Bombardment officers	419
Bombardment enlisted men	564
Pursuit pilots	315
Pursuit pilots, special equipment	164
Total	1462
Somatotypes	221
Total body size	5221
Facial Surveys	
Cadets	1454
Assorted aircrew	871
Negro R.O.T.C.	132
Total facial	2457
Women Flyers	
WASPs [1]	447
Flying nurses [1]	152
Total women	599
Grand total	8277

[1] Essentially same figures for body size and facial surveys.

clothing survey was emphasized by the fact that many garments are issued to specialized groups of aircrew — for example, electrically heated suits are worn only in bombardment airplanes. Since bombardment officers, bombardment enlisted aircrew (gunners), and pursuit pilots differ in size, and since the basic survey made no distinction among cadets, it was necessary to obtain clothing size schedules for each group separately. Accordingly, a detailed array of clothing measurements were taken during March and April 1944 on 315 pursuit pilots and 983 bombardment aircrew, 419 officers and 564 enlisted men.

3. Women flyers — WASPS and flying nurses. The increasing utilization of women in various flying capacities has posed further problems of selecting personnel and designing equipment; accordingly, 152 flying nurses and 447 WASPs (Women's Army Service Pilots) have been added to the body size surveys.

D. Facial surveys

During the original body size survey, a special problem arose in the fit of oxygen masks. So urgent was this that application of the body size data was postponed until the mask problem was well on its way toward solution. The transition from a "free-flow" to a "demand" oxygen system, in which economy is effected by supplying oxygen only on inspiration, meant that the mask had to fit the face as closely as possible. An additional necessity for close fit was imposed by tactical requirements of aircraft able to fly at ever higher altitudes, since the higher the altitude, the more serious becomes a given leak.

1. Aviation cadets. To afford a basis for an analysis of mask design and sizing, measurements useful for this purpose, as well as general head and face dimensions, were worked out by Drs. Hooton and Seltzer and Lt. Col. Gagge, and taken on 1454 additional cadets during April and May, 1942. The blank is reproduced in figure 3. Unfortunately head circumference was not originally included, since it had been taken in the body size survey, but was soon restored to its proper place in the head and face battery.

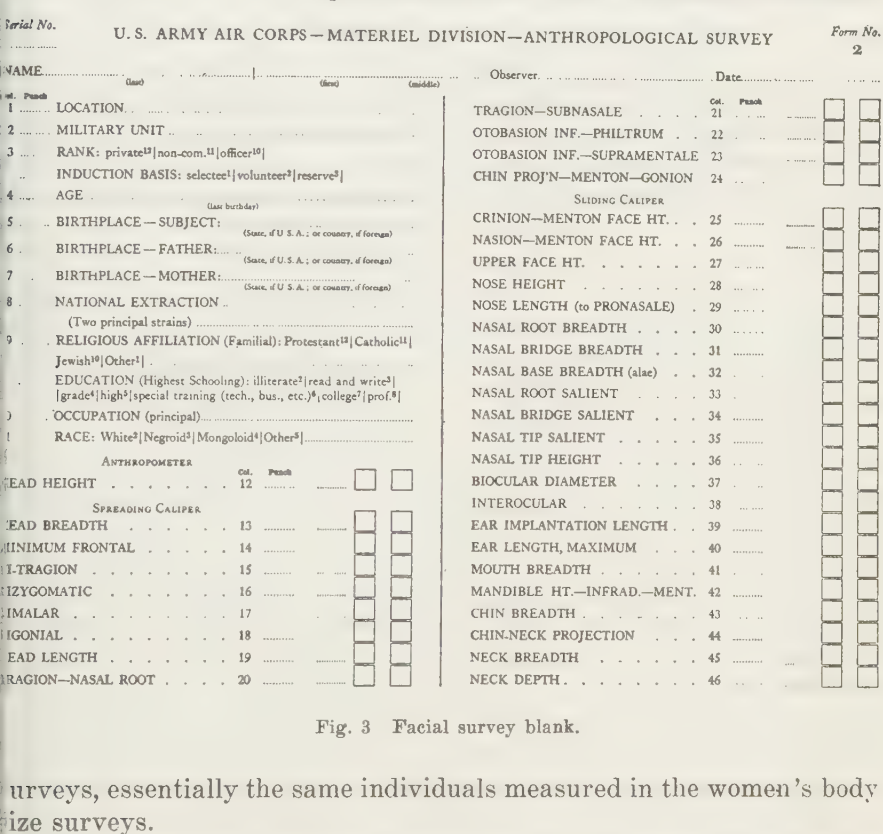
Just as the construction of manikins required supplementary body measurements, so the AAF head types (described in Section III-A below) required special head and face measurements (called "orientation" measurements, since they enable the points on the blank to be located in three dimensions), which were taken on a series of 196 (150 AAF flyers and 46 Aero Medical Laboratory personnel).

2. Negro R.O.T.C. cadets. The inclusion of Negro flyers in the AAF complicated the mask problem. Would standard designs and sizes fit Negroes? What proportions of the standard sizes would they require? To answer such questions, 132 R.O.T.C. cadets at Wilberforce University, representative of Negro AAF flyers, have been added to the facial survey. (It was found that Negroes are fitted by standard sizes but require a greater percentage of the large size than do whites.)

3. Specialized aircrew. Would older flyers differ from cadets in head and face dimensions? Would pursuit and bomber pilots have essentially similar measurements, or would a selective factor operate to alter the

proportions of mask sizes which should be issued to these groups? To answer these questions, 150 pilots, chiefly of bombers; 196 pursuit pilots; and 239 officers and 286 enlisted men of bombardment crews, have been measured in the facial survey, as have hundreds of photographic reconnaissance and other flyers at Wright Field for high-altitude indoctrination.

4. *Women flyers.* Similar questions in regard to women flyers led to the inclusion of 142 flying nurses and 440 WASP trainees in the facial



Serial No. ..... U. S. ARMY AIR CORPS—MATERIEL DIVISION—ANTHROPOLOGICAL SURVEY *Form No.* 2

NAME ..... (last) ..... (first) ..... (middle) ..... Observer ..... Date .....

Col.	Punch		Col.	Punch
1		LOCATION		
2		MILITARY UNIT		
3		RANK: private[12] | non-com.[11] | officer[10]		
		INDUCTION BASIS: selectee[1] | volunteer[2] | reserve[3]		
4		AGE (last birthday)		
5		BIRTHPLACE—SUBJECT: (State, if U. S. A.; or country, if foreign)		
6		BIRTHPLACE—FATHER: (State, if U. S. A.; or country, if foreign)		
7		BIRTHPLACE—MOTHER: (State, if U. S. A.; or country, if foreign)		
8		NATIONAL EXTRACTION (Two principal strains)		
9		RELIGIOUS AFFILIATION (Familial): Protestant[12] | Catholic[11] | Jewish[10] | Other[1]		
		EDUCATION (Highest Schooling): illiterate[2] | read and write[3] | grade[4] | high[5] | special training (tech., bus., etc.)[6] | college[7] | prof.[8]		
0		OCCUPATION (principal)		
1		RACE: White[2] | Negroid[3] | Mongoloid[4] | Other[5]		
		ANTHROPOMETER		
		EAD HEIGHT	12	
		SPREADING CALIPER		
		EAD BREADTH	13	
		INIMUM FRONTAL	14	
		I-TRAGION	15	
		IZYGOMATIC	16	
		IMALAR	17	
		IGONIAL	18	
		EAD LENGTH	19	
		RAGION—NASAL ROOT	20	

	Col.	Punch		
TRAGION—SUBNASALE	21			
OTOBASION INF.—PHILTRUM	22			
OTOBASION INF.—SUPRAMENTALE	23			
CHIN PROJ'N—MENTON—GONION	24			
SLIDING CALIPER				
CRINION—MENTON FACE HT.	25			
NASION—MENTON FACE HT.	26			
UPPER FACE HT.	27			
NOSE HEIGHT	28			
NOSE LENGTH (to PRONASALE)	29			
NASAL ROOT BREADTH	30			
NASAL BRIDGE BREADTH	31			
NASAL BASE BREADTH (alae)	32			
NASAL ROOT SALIENT	33			
NASAL BRIDGE SALIENT	34			
NASAL TIP SALIENT	35			
NASAL TIP HEIGHT	36			
BIOCULAR DIAMETER	37			
INTEROCULAR	38			
EAR IMPLANTATION LENGTH	39			
EAR LENGTH, MAXIMUM	40			
MOUTH BREADTH	41			
MANDIBLE HT.—INFRAD.—MENT.	42			
CHIN BREADTH	43			
CHIN-NECK PROJECTION	44			
NECK BREADTH	45			
NECK DEPTH	46			

Fig. 3 Facial survey blank.

urveys, essentially the same individuals measured in the women's body ize surveys.

5. *Other surveys, including movements.* The several large series bove constitute the basis for most of the current applications of body ize to the design and sizing of flying equipment. As already mentioned, maller series of twenty to fifty carefully selected individuals of the Aero Medical Laboratory are constantly being measured as special problems arise — for example, the amount of decrease in sitting height on looking straight up; the average slump from the erect "sitting

height" as measured in the survey to the normal relaxed sitting po tion; and special hand measurements necessary for glove sizing.

A class of data hitherto not very extensively studied, but of t utmost importance for aviation engineering (or, for that matter, hum engineering in general), is the range of movements in various operatio and positions of the body. Such studies have been made for the pro position and for the head and eye movements involved in sighting fro turrets.

III. APPLICATION OF ANTHROPOMETRIC DATA TO MILITARY AVIATION

The discussion in this section will be in rather general terms, part for reasons of military security and partly because the present pap is intended to be a summary account of the project as a whole. T applications are divisible into four main classes, which will be describ in turn.

A. General applications

Under this heading come classification and differential selection personnel; construction of full-scale head and body models represe ing AAF physical types; reports on body size in the AAF, for gene use by designers and manufacturers; range of movements in vario positions; and special projects not elsewhere covered.

1. Classification and selection of personnel. The correlation betwe physique and apitudes, outside the present scope of the Wright Fie project, has been explored by Major Sheldon (at the AAF School Aviation Medicine, Randolph Field, Texas) in regard to flying abili with indications that there may be a significant and usable correlatio If such is conclusively established, an enormous saving in time, mon and lives might be effected by early elimination of those unlikely succeed. At Wright Field, some interesting results have been obtain by correlating somatotype with susceptibility to decompression sic ness ("aero-embolism", or high-altitude "bends"), in which there great individual variation. Two series, 152 photographic reconna sance pilots and forty-odd University of Cincinnati medical studen have given similar results, and a third series, twenty-nine intensive tested Aero Medical Laboratory subjects, is now being studied. Wi flight ceilings rising ever higher, a successful classificatory procedu would be of considerable military importance. Possible further studi along these lines include correlations of physique with threshold "blacking-out" from high accelerative forces ("g"), and with susceptibility to motion sickness.

Selection of gunners for training in turrets and of women for pilot aining on the basis of body size alone has been investigated and will described in Sections B and C, below.

2. *Head and body models.* Full-male head and body models representing physical types of AAF flyers have proved to be a highly useful and widely used means of translating anthropometric tables o practical terms, and of thereby presenting the flyer to the designer aeronautical equipment as a tangible datum to be integrated with her objects that happen to be mechanical. It is generally true that the initial stages of airplane and turret design, all elements for the ulted space have been at hand and impossible to overlook except the er, who has, in consequence, been relatively neglected. Seven head d three plastic, jointed manikins have been constructed by a sculptor, r. G. W. Borkland of Chicago, working under the close supervision of e Wright Field anthropologists. All are exact to the millimeter in to 50 dimensions. Three manikins representing AAF women pilot- FASPs) are in preparation.

The seven head types have been described and illustrated elsewhere. Briefly, they were designed in connection with oxygen mask sizing. en some indication was needed of averages and extremes in fliers' ces. The basis for classification is nasion-menton face length, con- ered by all mask designers, and shown by actual experiment, to be e most important single dimension for sizing. The nasion-menton nge, from 101 to 146 mm., was divided into equal thirds, then the al three sizes of mask, theoretically non-overlapping, should be ed on divisions of the range rather than of the population. The erage face length of the middle third virtually coincides with that the whole group. The average of all other head and face dimensions flyers with the average face length is type I; types IV and V repre- t the average of every other head and face dimension for the short the long third, respectively, of face length. At the extremes, types and VII represent the shortest and longest few millimeters of face gth — (roughly, 1% of the group at either end). As for types II III, it had been observed during the course of the mask study that jective estimations of face length, frequently made and used by mask signers as a basis for sizing, were unduly influenced by face shape, at is, a narrow face was much more likely to be considered "long" n a broad face, regardless of the actual nasion-menton dimension. To strate the error inherent in such judgments, types II and III both e the (average) face length of type I; but type II represents the

smallest and type III the largest of every other measurement occurrin in faces of this average length (123, 124, and 125 mm.).

The practical orientation of AAF anthropology is well illustrated b the foregoing paragraph. Military requirements dictated the decisio to construct head types from the anthropometric data, as well as th selection of nasion-menton as the basic dimension; the division of th range rather than of the population, and into just three parts; and th choice of the seven head types within these divisions. This set of heac is but one of many that might be derived from the basic survey. Fc example, a set of four, based on head circumference and height, ha been constructed to serve as standard test blocks for helmet inspector and thus can dispense with counterparts of types II and III. Befor this set existed, a steel helmet for aircrew (see section II-D) based o type V (long third in face length), was adopted as standard and ha afforded a reasonably good fit for combat aircrew.

The three plastic, jointed manikins were originally requested b aircraft engineers for use in plane mock-ups, which are preliminar models where exact details of dimension and location are worked ou before the design is "frozen" for production. For cockpit clearance sitting height and leg length are the important dimensions, makin stature the best single basis for sizing the manikins. The stature rang from 156 to 198 cm. is divided into equal thirds; type A, with a statur of 175.3 cm. (69 inches), is the mean of the entire series in all measur ments; type B, 166.5 cm. (65.5 inches) represents the short third of th stature range and the short 17% of the series; type C, 186.3 cm. (73 inches), the tall third of the range and 9% of the population. The sta ture distribution of the population is asymmetrical due to the metho of selection of Aviation Cadets, who then had officially a lower lim of 64 inches and an upper of 76 inches, despite the presence of a fe individuals in the series outside these limits. Since a larger proportic of the population was excluded at the lower extreme than at the uppe division of this curtailed range into equal thirds places more subjec in the lower than in the upper third.

The manikins are made of cellulose acetate, a light, strong, and tran parent plastic. They are sturdy enough to be fitted with flying clothin and parachutes and can assume many positions such as standing, sittin or kneeling in the bombardier's position. Within the limitations in posed by their being based primarily on stature, they are applicab to many problems besides cockpit design involving body size. One us has been as dummies in firing tests of armor protection in airplane

Another type of manikin, a $\frac{1}{8}$ scale, two-dimensional, jointed figurine, s widely used in the aircraft industry to check dimensions in drawings ınd blueprints of airplanes. Such manikins, with dimensions based on he AAF survey and representing AAF flyers better than those previ- ›usly employed, have been constructed and supplied to aircraft design- ·rs for this purpose.

3. *Reports of body size in the AAF.* Two general reports on body ize in the AAF have been prepared. The first, a modified abridgement ›f the analysis of the basic body size survey prepared at Harvard under)r. Hooton's supervision, presents percentile values, from 5 to 95%, or each trait and includes correlation tables between pairs of measure- nents important for cockpit and turret clearances. This report is in- lispensable for laboratory research at Wright Field, but has proved oo technical for general industrial use. A second report, in simplified ·raphic form, omitting correlations and including increments added › each dimension by various flying clothing outfits, has been more uccessful for the latter purpose.

The experience gained in specific fields has been utilized in devising ther special reports in terms familiar to specific industries. Thus, imensions relevant to turrets have been presented in terms of struc- ural clearances and tolerances, while Tables of Clothing Sizes are › be prepared like those used in the clothing industry.

4. *Range of movements.* An entirely different undertaking, included nder "General Applications" only because it does not fit elsewhere in ne formal framework of the AAF anthropological program, is the study f movements involved in various positions of the body. Considerable nportance is attached to the prone position in aircraft, since the erodynamically ideal fuselage is severely constricted vertically, and ince effects of "g", or high accelerative forces, are better withstood ı the prone position. A study has been made providing basic data on ›mfort, visibility, and the variety and strength of movements attain- ble in the prone position, and head and body harnesses have been evised. A study of head and eye movements in sighting, made at the equest of a leading turret manufacturer, is described more fully in ection B-2, below. It has wide potential applications and illustrates nother type of fundamental research which physical anthropology can onduct for the mechanical engineer.

5. *Special projects.* As the source of information on body size in ıe Army Air Forces, the Aero Medical Laboratory receives frequent equests concerning dimensions of AAF flyers from various agencies. or example, techniques and data have been supplied to the Armored

Medical Research Laboratory, Armored Command, Army Groun Forces, for setting up a similar project; ear dimensions have been sup plied to the Navy (for earphones) and inter-pupillary distance to th Bureau of Standards (for goggles); and body areas and percentages c the most "vital" areas calculated for the three manikin types in con nection with wound ballistics and firing tests of body armor.

B. Aircraft gun-turrets

Turrets posed the major problem involving body size when the AA survey was undertaken, and the problem, it will be recalled, was two fold: to estimate percentages of flyers accommodated by existing equip ment, and to improve or design equipment to fit the maximum numbe Similar problems encountered in tank turrets led to a similar project b the Armored Forces, as noted above.

1. Selection of gunners. All standard AAF turrets and many exper mental ones were analyzed by selecting and measuring several ind viduals representative of AAF flyers, as found in the survey; outfittin them in standard flying gear; having them operate the turret as gunner would; noting the difficulties encountered due to crampin faulty location of mechanism, or uncomfortable position and mov ments; and comparing the relevant dimensions of subject and turr in such cases. These dimensions could then be located as percentile in the basic body size survey, percentages of AAF cadets and gunne accommodated could be estimated, and specific suggestions for improv ment made. After all the standard turrets had been so analyzed, it wa possible to recommend to the Air Surgeon upper limits on the heigh and weight of gunners, based on the knowledge that raising the limt above 70 inches and 170 pounds would result not in more gunners, b in more misfits. This recommendation was accepted. An interestin anthropological point is that, although neither height nor weight itself critical in turrets, the correlations between these dimension and those that are critical are so high (for AAF flyers) that the forme could serve as a rule-of-thumb for selection, without burdening medic examiners with specialized measurements like bideltoid, sitting heigh and buttock-knee.

2. Design of equipment. In virtually all turrets, it was found th changes which were minor mechanically and which could be made wit out materially slowing production would improve conditions greatl They were called to the attention of armament engineers at Wrig Field and in the industry, and many of the suggested modificatio adopted. The final step was to apply anthropological data to turr

design in the initial stages, since it is much easier to modify a blueprint or a mock-up than a production model. This has been accomplished in visits to major turret manufacturers, where reports on specific turrets and on the dimensions of AAF flyers and equipment have been discussed and transmitted; representative employees selected, measured, and their measurements located in the AAF series; and mock-ups of new turrets inspected and analyzed from the gunner's standpoint.

3. *Visibility.* The gunner's standpoint has come to include comfort, efficiency, visibility, and safety. The first two are covered by the analysis described above. The gunner's vision is obviously of supreme importance in turret design. Based on the normal eye position, visibility has been measured in all standard turrets and suggestions made for improvement. The "normal eye position" is fixed by the gun-sight location, the seat being adjustable up and down to bring the eye of gunners of varying sitting heights in line with the sight. But location of the gun-sight itself is supposed to be based on normal position and movements of the head and eye in sighting! Precise knowledge of the positions of head and eye when the gunner is sighting in various directions was lacking, with two results: (1) insufficient space was being allowed for the head, and (2) gun-sight movement during elevation and depression of the guns was frequently fatiguing to follow. At the request of a leading turret manufacturer, a study of sighting movements was made. The results have been distributed to all turret manufacturers and are being integrated with optical requirements in the design of turret domes and sighting panels.

4. *Safety.* Attempts to increase safety in turrets have been along three main lines: (1) design of parachutes to be worn in turrets; (2) facilitation of entrance, exit, and emergency escape; and (3) armor protection. Special provisions along all these lines are necessary if the turret gunner is to have the chance that is his due. Progress has been made in all three — for example, certain turrets now permit direct parachute escape, and special steel helmets have been designed for turret gunners. The development of special parachutes for turret wear is discussed in section D-3, below.

The steel helmet story is an interesting epitome of the entire AAF anthropological project. The high percentage of casualties caused by head wounds from low-velocity fragments led to the requirement that all bombardment crews wear steel helmets. Brigadier General Malcolm C. Grow, then Surgeon of the Eighth Air Force (and co-founder of the Aero Medical Laboratory at Wright Field) designed a light steel helmet to stop such fragments, based on AAF Head type V, of a set which

he found in the RAF Medical Research Center. At the same time, the Ordnance Department in this country modified the standard infantry helmet to fit over flying headgear. The latter helmet afforded more protection than the Grow design, but was larger; and the problem was whether one or two helmet types should be standardized. Data on head size and turret clearances gathered during the above turret study showed that the Ordnance helmet could not be worn in most turrets, whereas the Grow helmet could, thus assisting in the decision that two types are necessary. Other data, similarly gathered, are being utilized (1) to determine procurement percentages of the two helmets; (2) in the design of a new and smaller helmet by the Ordnance Department; and (3) in modifying the Grow helmet, now standard for turret wear, to fit the entire range of head size in AAF flyers.

The turret study is a continuing project at the Aero Medical Laboratory. Based on the studies just described, a set of requirements for gunners' provisions in local-control turrets has been prepared and has been distributed by the Armament Laboratory to all turret manufacturers as the Army Air Forces' version of good practice in turret design. In addition, some of these requirements are incorporated into formal specifications which must be met by all new local-control turrets. New turrets are routinely examined as they appear, and efforts to improve the gunner's lot continue.

C. Airplanes

This field, the surface of which has barely been scratched by the AAF anthropological project, offers exciting prospects for human engineering or "bio-mechanics". Much of the work to be mentioned is still potential. Because of the time lag between airplane design and production, and because of the military pressure for production, anthropological applications thus far have been chiefly concerned with accessories in production aircraft. Airplane design proper, a long-term project, has been studied mainly in the mock-up stages of experimental planes which may fly in a few years, if at all.

1. Selection of personnel. Investigations have been made of the need for imposing additional size limitations on pursuit pilots for certain planes, and of the desirability of placing a lower limit on size of women pilot trainees. It was found that neither limitation was required.

2. Troop seats for cargo aircraft. The military importance of air transportation of combat troops, passengers, and the wounded has

developed strikingly in the present war, posing problems in the economy of space that were hardly conceived of hitherto. In this connection, data have been supplied for the location and dimensions of seats and windows in cargo and troop-carrying planes. A new seat back has been designed based on dimensions of troops, proper location of supporting members, and provision for the assumption of postures minimizing motion sickness. Some of its features are being considered, pending final tests, by the Joint Army-Navy-British Aircraft Committee for installation in production cargo airplanes. The transition just illustrated, from size analysis to original design, has been observed (section III-A) in connection with prone position harnesses, and will be encountered again in oxygen masks, gloves, and the oxygen clip tab on outer garments.

3. *Mock-up inspections.* One of the most interesting of all the applications of anthropology to military aviation, but about which the least can be said, is the analysis of proposed and still secret airplanes from the flyer's point of view. Recommendations have been made and accepted on size and location of escape hatches, location and adjustment of pilots' seats, gunners' sighting systems, and movements and supports for various positions of the body.

4. *Studies in progress or planned; safety engineering.* From cramped turrets to crowded cockpits is a logical step in anthropological analysis. Data on pilots' dimensions have been made available to other AAF agencies conducting similar research, which includes "streamlining" cockpits to reduce crash injuries; design of seat for comfort, efficiency, and safety; and arrangement of windshields and gun-sights based on the pilot's eye position. It is hoped to compare visibility downward over the nose of various pursuit planes, with the aim of increasing this vital angle.

Proposed "safety engineering" studies include the establishment of minimum dimensions for escape hatches, based on measurements of large flyers in full gear; and a general project to determine location and dimensions of escape hatches, passageways, and installations to protect personnel during crash landing and "ditching" (forced landing on water).

D. Personal equipment

As might be expected from the nature of wartime research in military anthropology — a series of immediate, urgent requirements — personal equipment has received more attention than any of the other three major applications of AAF anthropology. In personal equipment, the relation of man to materiel is immediate and obvious. The projects

already described — selection of personnel, construction of full-scale models, gun-turret and airplane design — are relatively long-term undertakings, involving the indoctrination of military aviators and engineers in a point of view. Such studies can hardly be carried on when, for example, sudden tactical developments lead to an urgent request from a combat theater for a large number of oxygen masks or garments that are still experimental, and the number of sizes, dimensions of each size, and proportions of each size in the total must be "immediately" worked out; or when manufacturers are continually submitting pre-production samples of garments which must be tested for size before production may begin; or when past deficiencies must be remedied or new ideas incorporated as soon as possible in the full course of production, where every day means thousands of items. Quite properly, most of the time and volume of work of the AAF anthropological program is devoted to personal equipment.

1. *Oxygen masks.* The following brief account of the oxygen mask study can only indicate some highlights of this intriguing problem. The first attempt to apply anthropometry to aviation medicine, its emphasis has long since shifted from analysis and evaluation to original design. Even before the head models were constructed, all available masks, Allied and enemy, were thoroughly tested for fit on sizeable series of individuals measured according to the Facial Survey Blank (fig. 3). Successes and failures of each size of each mask were related to facial dimensions, and proportions of AAF flyers fitted could thus be estimated. Recommendations were made for re-designing and re-sizing, and specific data supplied, with the result that subsequent masks have a much greater percentage of fits. It was determined that three sizes are necessary for AAF masks, and the percentages of these sizes have been established for general production and for issue to specific groups of flyers. It has been found, for example, that fighter pilots and especially photographic reconnaissance pilots require a larger proportion of small and medium sizes than do bombardment crews.

Based on anthropometric data and on consideration of the goggles and helmets with which masks must be integrated, a new mask has been designed and developed about which little more can at present be said than that it is well past the experimental stage and in operational use. It has proved to fit virtually all AAF flyers, including women, and to be suitable for a number of purposes, including resuscitation of unconscious flyers. Other types of masks, such as a full-face mask incorporating goggles, for waist gunners; and combinations of plastic and rubber materials, are being experimentally designed.

2. *Clothing.* a. Fit. Anthropometric data have been translated into tailors' measurements in Tables and Sizes and Percentages for AAF Flyers, supplied to the organizations developing, engineering the production, and procuring AAF flying clothing. Jackets, trousers, helmets, and gloves have thus been sized, and a table for shoes is planned. These tables are routinely utilized in the design, sizing, procurement, and issue of flying and other clothing for AAF flyers. Thus, the number of sizes required and the dimensions for each size will be tentatively established for a proposed garment, based on knowledge of its function, design, material, and associated clothing. A sample of each size is made and tested on subjects of known dimensions, and the size schedule modified as required — more or fewer sizes may be necessary, or different dimensions indicated. These dimensions are included in the specifications. Finally, the percentages of each size in the total production is determined. A similar program for women's clothing is under way.

As for actual production garments, samples of flying helmets are routinely submitted for size tests before manufacturers may begin full production, and periodic samples of all garments are routinely inspected for conformity with the dimensions in the specifications. A study of glove sizing has led to the construction of model hands and to experimental design of gloves with curved fingers. A lighter touch has been afforded by the determination of the required range of adjustment in suspenders to be worn with high and low waisted trousers.

b. Bulk. A consideration frequently overlooked by airplane, turret, and clothing designers is the bulk inherent in most flying clothing. It has been found that even in electrically heated clothing, adequate insulation entails bulk which, in the limited spaces available, cannot be disregarded and may actually impede efficiency. Increments added by various standard outfits (shearling, electrically heated, and down-filled) to each dimension measured in the body size survey, have been determined and compared. These figures indicate relative percentages of the various outfits for the total clothing program, since the bulkiest cannot be used in certain crew positions; form an indispensable supplement to body size measurements used by airplane and armament engineers; warn the clothing designer of the limitations imposed by aircraft; and indicate regions of the garment where bulk might be reduced.

c. Flexibility. A problem allied to those of bulk and fit of clothing is the comparative flexibility of various outfits, for which a program of study has been devised. Limited space and the weakening effect of

extreme altitude, even when pure oxygen is supplied, makes this problem acute in military aviation.

3. Parachutes and harnesses. The initial turret investigation has led, as already noted, to work on steel helmets and on bulk in flying clothing; a third avenue has been toward parachutes for turret wear. Limited space has made it virtually impossible for gunners to wear parachutes over adequate clothing in some aircrew stations which offer the best opportunities for emergency escape! Expressly designed parachutes have been solicited, tested in turrets by selected subjects wearing various clothing outfits, and further recommendations made to the designers.

The required sizes and range of adjustment for parachute harnesses have been studied, and work is contemplated on the integration of the one-man life raft with the parachute harness, and on the design of the life raft itself.

4. Special equipment. Under this heading come anthropometric data applied to a number of projects on which considerable work has been done but which will merely be listed in order to keep the present paper within reasonable bounds. These projects include: (a) body armor; (b) goggles; (c) location of earphone sockets on helmets; (d) special combat devices for pursuit pilots; and (e) a project stemming from work on clothing and only remotely anthropological; namely, the design and location on outer garments of a tab for attachment of a clip at the juncture of the flyer's oxygen equipment with that of the ship

IV. SUMMARY AND GENERAL CONCLUSIONS

The background, history, and operation of physical anthropology in the Army Air Forces have been briefly summarized. Initiated as a consequence of pressing military problems involving human dimensions, the basic procedure was an anthropometric survey of Army Air Forces flyers, several thousands of whom have now been measured. These measurements have been applied to the selection of personnel and to the design and sizing of military aircraft and associated equipment, including gun-turrets, oxygen masks, flying clothing, and parachutes, with the aim of increasing the comfort, efficiency, visibility, and safety of flying personnel. The Army Air Forces anthropological program has served as a model in the organization of a similar project by the Armored Command, Army Ground Forces.

A few general remarks may be in order. Much has been learned since the early attempts to use anthropological terms in discussion with aeronautical and mechanical engineers and with clothing designers.

Technical anthropological language is now avoided as completely as possible in such discussions, although it is necessary for precision among anthropologists themselves. Even when carefully defined, it has been found to interpose a serious barrier between the anthropologist and those who seek his advice. Not only technical language, but some traditional anthropometry has also been discarded when it became evident that techniques and measurements originally devised for evolutionary and racial investigations are not necessarily applicable to human engineering problems. At the same time, new ones have been devised when required, some as far from classical anthropometry as are the problems they help to solve.

Several trends have characterized the Army Air Forces project. (1) There has been a consistent transition from analysis and evaluation of existing items to original design of new equipment, exemplified in connection with cargo airplane seats, oxygen masks and clip tabs, and prone position harnesses. (2) The original problems have ramified into many fields related only through the human element. Turrets have led to studies of clothing bulk, steel helmets, and parachutes; oxygen masks, to work on all head and facegear; clothing, to oxygen equipment; and size analyses of specific turrets, to safety engineering in general. This emphasizes that the designer of equipment for human use should begin with man himself, rather than relegate him to the subordinate position in which he is too often found. (3) As a consequence, the physical anthropologist can occupy a central position as human engineer, as exemplified by the numerous liaison functions he has come to perform in the Army Air Forces. For example, parachutes and gun-turrets had been designed separately; so had goggles, oxygen masks, and helmets; so had flying clothing and oxygen equipment. Anthropologists have initiated the integration of all these sets of materiel.

The physical anthropologist can furnish to the product engineer information on the size and shape of the human body and on the nature and range of normal movements. Once such information becomes available and its existence and source generally known, it has been found that engineers and designers of all types of equipment are most coöperative in requesting and utilizing anthropological data. Nor are the practical applications of physical anthropology limited to military equipment; ineed, civilian products offer a much wider field, since comfort and satisfaction of the individual are of even greater moment. Physical anthropology may well expand its war-time contribution into a permanent feature of man's design for living.

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REVIEWS

THE SKULL OF SINANTHROPUS PEKINENSIS; A Comparative Study on a Primitive Hominid Skull. By FRANZ WEIDENREICH. Palaeontologica Sinica, New Series D. no. 10, Whole Series no. 127, 1943, xxi + 298 pp., 38 tables, 93 figures, 245 references, index.

For a long time it has been apparent that the choice of Professor Weidenreich as successor of the late Davidson Black, to continue and carry to completion the studies of Sinanthropus, was an appointment so wise as to suggest selectional genius in those that made it. It is to be hoped that in postwar days explorations of the Sinanthropus sites may be continued and that Professor Weidenreich will go on with his brilliant studies of the specimens recovered. However, for the present, this large monograph on the Sinanthropus skulls marks the culmination of a project begun in 1927 that has added more to our knowledge of human evolution than it seemed possible that a single small area could contribute.

Professor Weidenreich has had the opportunity of studying not only the incomparable Sinanthropus collection, but, in a preliminary way, also the new Pithecanthropus and Soloensis material, the most of which has been published incompletely, and some of it not at all. Weidenreich's vast knowledge of human palaeontology make his remarks and comments on the Java material, which has been used for comparison with Sinanthropus, the most authoritative statements up to now upon the other great oriental collection of remains of earliest man. Hence, this book on Sinanthropus is in reality a treatise upon the whole subject of palaeanthropic man and a detailed exposition of the author's views upon human phylogeny.

The material dealt with in detail in the monograph includes fourteen incomplete skulls of Sinanthropus, of which five are calvariae and the rest are represented by one or more fragments. The teeth and mandibles of Sinanthropus have been studied by Weidenreich in earlier publications.

The part on the structural characters of the Sinanthropus skull includes masterly descriptions and analyses of the morphology of the calvariae in the various norms or aspects, of the separate cranial bones, and of the facial skeleton. This section also deals with the reconstruction of the face and skull of Sinanthropus, with the metric and craniographic data; the "architectonic" structure of the skull; age, sex, and individual variation; and the causes of the fragmentary condition of the material.

Part III compares the Sinanthropus skull with that of other forms of fossil man and with the skulls of anthropoid apes. Whereas the bulk of the work consists of morphological description and metric data that may be accepted as final and definitive, the comparative section is interpretative and includes many opinions and conclusions that may be contested by other students. It is interesting and amusing to note that the amiability and gentleness of personality which Professor Weidenreich invariably manifests in personal contact contrast

somewhat with the tone of his writings upon controversial scientific subjects. His dialectic style is more bellicose than conciliatory — a characteristic that enhances the enjoyment of the innocent anthropological bystander.

The reviewer cannot hope to summarize this great work, nor does he presume to criticize, because the readers of the Journal want to know what Weidenreich has discovered and what he thinks rather than the reactions of the present writer to aforesaid facts and opinions. However, it is in order to quote some of Weidenreich's postulates and to skeletonize his more important conclusions.

Page 1. Introduction. "In determining the character of a given fossil form and its special place in the line of human evolution, only its morphological features should be made the basis of decision; neither the location of the site where it was discovered nor the geological nature of the layer in which it was embedded are important." (Reviewer's comment: ! ! ! !) . . . . "It is a generally accepted conception that Man has developed in the course of time by gradual transformation from an ape-like type to the type he presents today. Viewed from this fundamental standpoint, it is logical to assume that the more a form resembles the supposed ancestor the more ancient it will be, or that the more ancient it is the more 'primitive' it should be." . . . . (page 3) "Therefore, when the word 'primitive' is used in this paper, it should be understood to mean only 'closer to the original form of man,' irrespective of man's relationship to other primate forms." (Reviewer's comment: ? ? ? ?)

Conclusions. Page 273. "*Sinanthropus* and *Pithecanthropus* are the most primitive hominids so far known. Of the 121 main characters of the *Sinanthropus* skull — excluding mandible and dentition — . . . . . 74 can be checked in *Pithecanthropus* . . . . In 57 out of these 74 main characters *Sinanthropus* and *Pithecanthropus* completely agree. Eight characters are doubtful and five accidental ones." . . . .

"'*Eoanthropus*' should be erased from the list of human fossils. It is an artificial combination of fragments of a modern-human braincase with orang-utang-like mandible and teeth. *Sinanthropus* and *Pithecanthropus* show that relatively advanced types of mandible and teeth can be part of a skull with a primitive braincase, but the conditions are never reversed."

Page 274. "The braincase of *Pithecanthropus* is generally smaller and its walls thicker than is true in *Sinanthropus*, ... the average cranial capacity amounts to 870 cc. in the former as against 1075 cc. in the latter . . . . The *Pithecanthropus* frontale is flat and continues almost directly into the frontal torus while that of *Sinanthropus* has developed a bump-like protruding tuberosity separated from the frontal superstructure by a distinct groove. The air-sinus is very spacious in *Pithecanthropus* but small or completely wanting in *Sinanthropus* . . . . *Pithecanthropus* and *Sinanthropus*, therefore, are representatives of about the same general stage of human evolution but of two different regional or racial variations of that stage. Which form is the more primitive cannot be decided while the *Pithecanthropus* material remains as scanty and as fragmentary as it is at present."

"*Homo soloensis* (Ngandong skulls) cannot be placed in the Neanderthal group but represents a rather more primitive type. . . . . It differs from *Sinanthropus* in the same characteristics in which *Sinanthropus* differs from *Pithecanthropus*. *Homo soloensis* appears, therefore, as an enlarged *Pithecanthropus* type on the way to an advanced form."

"The group of fossil hominids usually designated under the collective name "Neanderthalians" fits comfortably in the line of human evolution with *Pithecanthropus-Sinanthropus* on the base and modern man at the top."

Page 275. "The limb-bones of all fossil hominids, speaking only of those the attribution of which is not doubted, exhibit a perfectly human character. . . . This indicates that the adoption of an erect posture far preceded the transformation of the skull."

Page 276. "There is no evidence of any specialization or side-branching in the develment of homid (sic) forms from the *Sinanthropus-Pithecanthropus* stage up to that of modern man."

" . . . . there are clear evidences that *Sinanthropus* is a direct ancestor of *Homo sapiens* with closer relation to certain Mongolian groups than to any other races."

This truly great work of Weidenreich has rendered all students of early man his debtors. At a time when Physical Anthropology in the United States has recently suffered the loss of several of its pioneers and leaders — Todd, Pearl, Hrdlička, and Davenport — our branch of science has reason to congratulate itself that Franz Weidenreich, one of the best European anthropologists, is now domiciled in its midst and ready to lead it forward.

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THE PROBLEM OF ANTIQUITY OF MAN IN AUSTRALIA. By D. J. Mahony, Mem. Nat. Mus. Melbourne, no. 13, 1943. pp. 7–56, 7 figs., 3 pls., 212 refs.

THE KEILOR FOSSIL SKULL: ANATOMICAL DESCRIPTION. By J. Wunderly. Mem. Nat. Mus. Melbourne, no. 13, 1943, pp. 57–70, 1 fig., 9 pls., 2 tables, 12 refs.

THE KEILOR FOSSIL SKULL: PALATE AND UPPER DENTAL ARCH. By William Adam. Mem. Nat. Mus. Melbourne, no. 13, 1943. pp. 71–78, 4 figs., 2 pls., 7 refs.

THE KEILOR FOSSIL SKULL: GEOLOGICAL EVIDENCE OF ANTIQUITY. By D. J. Mahony. Mem. Nat. Mus. Melbourne no. 13, 1943, pp. 79–81, 5 refs.

Eleven miles northwest of Melbourne, near Keilor, two mineralized skulls and some other human bones were found in 1940, 19 feet deep in a sandpit in the third or Keilor or 45-foot terrace (103 feet above sea level) of the Maribyrnong River. One skull, complete except for mandible, is described and discussed in the above reports. The other, and most of the bones, "have not yet been received by the Museum."

The Keilor and two lower terraces (36 and 27 feet) "correspond" with the 40- to 50-foot raised beaches of northern Tasmania which have been correlated by Edwards with the Riss-Würm interglacial. Their differences in elevation "may represent" eustatic fall in sea level towards the end of the interglacial. These correlations are specified as tentative (p. 80).

The skull is described in two tables of measurements with comparative means of Australians, Tasmanians, Papuans, Melanesians, and three groups of Polynesians; by six photographs and three plates of life-size contours; and by several pages of text discussion. The outstanding characteristic is the size: capacity (Lee's formula no. 10) 1593, length 197, breadth 143, basion-bregma 143, circumference 544, nasion-opisthion are 389. These figures surpass all the racial means cited in comparison, except that the Hawaiians equal Keilor in breadth. Wunderly adds that Keilor exceeds all the means in seventeen of twenty-eight measurements. In the three diameters it approaches the maxima recorded among 1000 Australian skulls measured by Hrdlička, being exceeded in length by the maxima for five of six regional groups, in breadth by one in six, in height by four in six. That is, only ten of these particular eighteen maxima are greater than the Keilor individual.

The photographs indicate a fair mastoidal but only moderate superciliary development, though Wunderly says that the latter is "more prominent than is usual" in South Australian skulls. He notes that "the extreme features" of many male Australians — acute keeling of the vault, rough areas of muscle attachment, general ruggedness of bone construction — are lacking.

Inspectionally, the most striking features of the Keilor specimen is the smallness of the rectangular and downward sloping orbits. This is borne out by orbital diameters — 39.5 and 30 — which, in spite of the size of the skull, are less than the means for six Australian regional groups; less also than the means for five Papua-Melanesian-Polynesian groups cited; and barely surpassed only by a series of Tasmanians whose capacity is 350 cc. less.

All in all, the skull does not seem specially primitive either by Australian or by general human phylogenetic standards; especially for a pre-Würm age.

All three of the authors are considerably exercised by the question of Tasmanian versus Australian resemblances in Keilor; not because the Tasmanian similarities are obtrusive, apparently, but because of some speculative hypothesis as to Tasmanian-Australian racial relations which seems to be momentarily in the forefront in Australian thought, just as it agitated Wood Jones into devoting to its refutation most of his review in Nature. This local issue will no doubt ultimately come into its own so far as it deserves. For the present it seems calculated to distract Australian workers from the major problem of placing the discoveries of their continent more definitely in the total scheme of human development.

And Mahony at least does seem interested in this larger problem, as evidenced by his first paper. He considers Talgai wholly unsatisfactory as regards geological evidence, and cites Wood Jones' finding of its falling within the range of variation of recent aborigines. The same holds for Cohuna, according to Shellshear and T. D. Campbell: Sir Arthur Keith's account of Cohuna being based not on the skull itself but on "some data, with measurements and a tracing along the middle line of the skull;" this tracing was made before removal of a mineral incrustation (up to a quarter of an inch thick), which is said to have been mistaken for bone. Mahony himself in 1936 reported "no evidence of geological antiquity" at the site.

The net effect on the reviewer of the evidence produced in these four important papers is one of skepticism whether Australia has yet yielded anything

really ancient either in time or in type of human development. The bones found seem at least as close to those of historic natives as Upper Paleolithic skulls are to those of historic Europeans. Their period may, like that of Cro-Magnon man, extend back into the very terminal Pleistocene. There seems to be no compelling evidence in hand for anything earlier or for anything developmentally less advanced in Australia; nothing as old or as definitely non-modern in type as say Neandertal or Solo. Size seems to be the one outstanding trait of Keilor as of Wadjak and of the Talgai and Cohuna palates; and since size recurs as characteristic of Cro-Magnon and Afalou, of Neandertal, Solo, and Broken Hill, one wonders whether bigness actually marked one stage of human evolution or whether it was the big and rugged skulls that got preserved.

However that may be, this group of monographs on Keilor is important.

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MAN'S MOST DANGEROUS MYTH: THE FALLACY OF RACE. By M. F. Ashley Montagu. Columbia Univ. Press, New York, xi + 216 pp., 1942 ($2.25).

RACE: SCIENCE AND POLITICS. By Ruth Benedict. The Viking Press, New York, xi + 273 pp., revised ed., 1943 ($2.50).

THE RACES OF MANKIND. By Ruth Benedict and Gene Weltfish. Public Affairs Committee, Inc., New York, Pamphlet no. 85, 31 pp. (10c).

RACE, REASON AND RUBBISH. By Gunnar Dahlberg (translated by Lancelot Hogben). Columbia Univ. Press, New York, 240 pp., 1943 ($2.25).

The titles of the four recent books listed here have one word in common: race. Yet the books will be found to lack detailed data on the races of mankind and even in some cases a definition of the word "race" itself. Their main purpose is to expose racism, by which is meant the perversion of the scientific race concept for political purposes. These books are thus closely identified with the world struggle through which we are now passing and are intended for a popular rather than scientific audience. Their differences in approach — whether genetical (Dahlberg) or historical (Benedict) — and scope — whether 31 pages at 10c or 273 pages at $2.50 — give the reader a considerable range of choice. Such facts as are marshalled for the purpose at hand appear to be correct.

Only one of these books, that by Montagu, calls for more extended mention here, for the reason that its author accuses the physical anthropologists of pre-Mendelian thinking as regards race. In the first two chapters of this belligerent treatise Montagu attempts to show "the meaninglessness of the anthropological conception of race" by identifying it alternately with biological taxonomy and racism, and at the same time holding up for comparison what to his way of thinking is the only useful concept, namely, that of genetics.

As Benedict says (Race: Science and Politics, p. 32), "Racial classificatio of the human species has an honorable background." Furthermore, moder anthropologists, far from limiting their attention to outmoded taxonomic pr cedures, are following with intense interest the new developments in huma genetics. One has only to look at the literature on blood groups, which wa one of the first human genotypic characters to be understood, to see that a thropologists have contributed their full share to these investigations, in spi of the highly specialized procedures involved. Nevertheless, the human genet characters that are sufficiently understood to be usable for gene distributio studies, and hence racial classifications in the genetic sense, are still very limite in number.

On the other hand, physical anthropologists are being confronted with th practical probem of describing phenotypic group differences, both in the livin and in the osseous remains. In tackling this problem they are not necessaril concerned with human phylogeny as such; they may be working on a local pha of history in conjunction with archeologists; or they may be studying the e fects of environment on the organism. Merely because they resort to the proce of averaging measurements, for lack of a better tool, they can not be said to b indulging in "race making" as Montagu claims.

It is undoubtedly true that physical anthropologists lose sight at times o genetic principles, and also that they sometimes use the word "race" ver loosely. The chief value of this book to the professional is its reminder of the failings. However, this is quite a different issue from racism, which is the ma theme of the book, and its use as an introduction to the latter subject serv only to confuse the general reader.

T. D. Stewart

HUMAN CONSTITUTION IN CLINICAL MEDICINE. By George Drape C. W. Dupertuis and J. L. Caughey, Jr. Paul B. Hoeber, Inc. Medic Department of Harper and Brothers, New York. xi + 273 pp., 31 tables, 2 figures, bibliography. 1944. ($4.00)

In a well-presented discussion of the case for constitutional studies in clinic medicine the authors have concerned themselves primarily with describing se eral of their approaches to the study of the biology of man. Some material whic had been published separately in various medical journals from the Constitutio Clinic of the Presbyterian Hospital has been rephrased and quoted directly.

It is an essay concerned with clinical medicine, yet one which deals especiall with the nature of the "man within the patient." In the preface the autho state their objective and note that they "have tried to utilize any dependab and appropriate method which is applicable to the various aspects of the o ganism . . . In morphology, for example, the anthropometric technique o Martin, the photographic somatotyping technique of Sheldon, and an overa observation and correlation of feature detail and relationship, and of hair, pig ment, teeth and joints" have been employed.

Unquestionably this work is stimulating to all workers in constitutional studie The chapters entitled: "Growth, Development, Decline and Death; Mosaic o

ndrogyny; Problems of Observation, Correlation and Interpretation; Anthro-ometry; Somatotypes; and Problems and Examples in the Clinical Use of Con-titution Studies" will be examined most carefully by physical anthropologists, ho must bear in mind that the authors are addressing themselves particularly medical students.

Anthropometric measurements on 244 male and 585 female patients were nalyzed. They were studied by disease groups wherever 20 or more subjects ould be included from those chosen at random among the hospital's patients ho were over 20 years old and of European ancestry. The authors have not ublished the full statistical tables in which significant differences for disease roups were shown. This is to be regretted, but the tables "are preserved for nterested investigators at the Constitution Clinic of the Presbyterian Hospital." nstead of this more conventional presentation, a scale of seven equal grada-ons was used where the measurements were calculated in percentage of stature, procedure considered to be valid, inasmuch as there was almost no variation n average stature for the different disease groups. For every increase of 10% n the measurement-stature ratio the gradations in the scales were expanded .10 units. The table of scales used in the study is given. Such arrangement f material facilitates comparisons and presents in compact tables significant re-ationships among the disease groups offered for study.

The somatotyping studies followed the technique of Sheldon and extended ver 4 years. The three components are here described as I- soft roundness, II-uscular solidity and III- linearity (delicacy) in place of the terms endo-morphy, mesomorphy and ectomorphy formerly used. This seems to be a desira-le step as it gives a simpler descriptive value to the designations and avoids ny implication of the nature of the causes producing the three basic bodily naracters under assay. Records of 195 male and 126 female patients were rouped as they were for the anthropometry analysis, by disease types. Aver-ges for the rating of the emphasis of each component in each physique on a ven-point scale serve to form an "average somatotype" for the different roupings. Distributions are given only for the duodenal ulcer and gall bladder omatotypes of the male series. The whole chapter presents confirmatory evi-ence of the utility of the somatotyping analysis for some constitutional inves-gation. It is to be hoped that studies of larger series in which more detailed ports can be spread out will be published as the work of the Constitution linic proceeds.

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INCOLN: DOUGLAS, THE WEATHER AS DESTINY. By William F. Petersen. Charles C. Thomas, Springfield, Ill., X, 5–211 pp., 1943. ($3.00)

It is impossible in a review to do justice to this unique and original departure the field of scientific history and biography without referring now and then the author's series of medical treatises entitled "The Patient and the Veather" (Edwards Brothers, Inc., Ann Arbor, Mich., 1934–38). As a physiol-

ogist and pathologist, a biochemist and meteorologist, Dr. Petersen expounds in "The Patient and the Weather," with all the meticulous detail involved in clinical research and medical writing, his thesis that the individual human organism is a "cosmic resonator", not esoterically but quite simply an earth-bound organism that is creature and pawn of the tides of solar radiation affecting our atmosphere.

All great explorers at times lose their perspective in enthusiasm for their goal and to this Dr. Petersen is no exception: but his research is an exhilarating adventure to follow, a course plotted and steered by an expert hand and on which physical anthropologists in particuar may well watch with a "weather eye." It is no derogation of the major theory involved or the brilliant research and handling of experiment and data, to say that many anthropologists, from a variety of angles — historical, cultural, racial, social, psychological — can and some undoubtedly in the course of time will, successfully attack and undermine some phases of the confortable compactness and assurance of this new version of environmental determinism. Despite the fact that Dr. Petersen says in the conclusion to his study of Lincoln (p. 163) "I have stressed . . weather, not because it is all important, but because it is one of the neglected forces," the weather is clearly for the author a creative as well as a limiting factor in evolution and history. There is some comfort, however, in observing that lean, sensitive Lincoln, though victimized by weather, beat stout "well buffered" Douglas politically, outlived him and by his deeds became immortal whereas Douglas by reason of his immunity to weather and his comfortable constitution exhausted himself and fell short of his destiny. It seems, then, that a Lincoln is also resonator for something more potent than weather, implicit in the genes and hence also cosmic, expressed as will and character.

Dr. Petersen is rendering anthropology a great service in pointing the way to a return to the study of Man as individual organism evolving and existing in the matrix of environment. The "Lincoln: Douglas" assay, in which Douglas, Lincoln's political opponent and opposite as a constitutional type, and also his wife Mary Todd (also an opposite type) serve as foils in the drama, is the study of three individuals — their heredity, their characters and their careers as affected by weather coincidental with the major events of their lives. What lies behind this popular exposition, in study and research, is to be found summaried in Part 2 of Vol. I of "The Patient and the Weather": Chapter I, the Individual, and Chapter XV, The Human Organism as a Cosmic Resonator. (This volume of the series is the one most significant for anthropologists. It covers also Constitutional Type, the meteorological approach and the biological principles involved in Petersen's study.) It is in focussing his study of meteorological factors as affecting Man upon the individual that our author differs from Ellsworth Huntington and his demographic, geographic environmental studies, and from Griffith Taylor with his geographic, climatic and ethnographic perspectives.

Weather-sensitive Lincoln was "The Slender Type," robust Douglas "The Broad Type" (pp. 10–17, 29–33). In his medical treatise ("The Patient and the Weather," Vol. 1, Part 2, p. 5) our author writes, "This bipolar grouping which Stockard has emphasized, is not only biologically sound but clinically use

ful . . . " After this follows his classification of the traits characteristic of the opposite types. (The "Slender" is dolichocephalic, by the way, the "Broad" is brachycephalic. How charmingly simple, anthropologically! What of the genetically stable ethnic types that contradict this pleasing simplification?) Returning to the bipolar grouping, in Petersen's scientific terminology the "Slender" is Leptosome and the "Broad" is Pyknic. "For the 'in-between types' we use the designation 'normosome' or 'athletic' type: It actually represents a blend." (Chapter I of Vol. 1, Part 2, of "The Patient and the Weather" analyses the problem.)

While the confusion that exists in medical and anthropological research with respect to constitutional type actually affects very little the weight or validity of Petersen's evidence supporting his thesis that opposite constitutional types react differently to meteorological controls, nevertheless his commitment, because it is "clinically useful," to the over-simpified concept of bipolarity may prove to be one of the weakest points in the rigorously thorough and carefully integrated structure of his scientific exposition. But what can a medical man do but choose a classification that is "clinically useful" and appears to be biologically sound, unless and until somatologists set up universally acceptable criteria? It is this that Sheldon has undertaken to do, with respect to Constitutional Type. Physical anthropologists, like the cyclonic storms of our latitude, are blowing hot and blowing cold with respect to Constitutional Type: some hot in criticism and condemnation, others cold in disdain. Yet who is to perform the necessary service of definition unless it be anthropologists, collaborating with anatomists and clinicians?

Social anthropologists ought to study Petersen thoroughly: but they will turn a "polar face" to his doctrine that weather makes the man. If Petersen is right, if weather at time of conception, storm tracks and sun spots determine the nature and behavior of the individual, govern his "destiny," then society as an aggregate of individuals is not merely influenced by the "weather" but the destiny of Man, civilization and history are determined by it. I wonder whether Dr. Petersen has thought this phase of his theory through? He is historically-minded, for one of the most interesting features of his long range thinking is his correlation of certain major events in human affairs in the long perspective of history with cycles of solar activity. As an anthropologist (but not a sociologist), I feel that the most vulnerable point in Petersen's masterly array of fact and theory is his failure to weigh sufficiently cultural, social and strictly psychological phenomena as primary factors affecting individuals and society. This failure is not a result of Dr. Petersen's lack of insight, I am sure, but of the discipline in which he was conditioned and in which he works, namely modern medicine. The cold, damp shack with dirt floor in which Lincoln was born, the lean diet (alimentary, social and intellectual) of a "po' white" family such as that of Thomas Lincoln, his wife Nancy Hanks and their son Abraham — these living conditions, characteristic of what used to be referred to in Virginia as "hog and hominy" explain as much to me as the weather. I shoud like to see an anthropologist, capable of weighing fairly all the factors of cultural and physical type and environment, interpret Lincoln. I believe such a study would convince Dr. Petersen that Lincoln's leanness, fatigue, lack of stamina, his temperament were not only caused by genetic fac-

tors determining Constitutional Type, plus weather, but were due in part, and in no small part, to poor diet and the meagre, uncomfortable living habits characteristic of early American pioneer dirt farmers; that his physical and mental handicaps are also in large measure attributable to social, cultural and intellectual starvation and warping of a mind and spirit with very superior potentialities cast in soil almost devoid of requisite cultural nutrients.

Dr. Petersen reveals himself in "The Patient and the Weather" as a man of rare originality with a thoroughly scientific attitude, clear vision and superior ability to report the results of his complex clinical and documentary research and wide scientific and scholarly learning. In "Lincoln: Douglas" he proves himself to be a writer of the first order whose imagination can lift and stimulate his reader without leaving the firm footing of demonstrable fact. The running text of this volume containing story, argument and essential evidence is lucid and clear. Numbers in the text refer to lengthy notes in the Appendix, meteorrograms, and historical and biographic data illustrating and supporting the statements in the text. The book is unique and original in its arrangement: supporting proofs, documentation and bibliography are all there but not too obtrusive for the serious but uninformed layman. In this alone many scientists will find the book worth looking at. Once looked at, it is likely to be read.

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MANKIND SO FAR. By William Howells. The American Museum of Natural History, Science Series. Doubleday, Doran and Company, Inc., Garden City, N. Y. xii + 319 pp., illustrated with drawings and photographs. 1944. ($4.50).

Dr. Howells has made the best contribution to date toward supplying a general and elementary yet scientifically reliable work on a subject in which man is most interested — namely, the history of his species and of the living races and a prediction of what he will become. The title, MANKIND SO FAR (the underlining is mine), is particularly well chosen in that it implies the very important fact that man is still in the process of evolving.

Lucidly, interestingly, often humorously, and with the utmost simplicity for such a complicated subject, he traces the hominid line from the fishes to the present races. He gives a clear cut picture of the vertebrate world as a whole and man's relative position in it. This develops in the reader the anthropological point of view of objectivity and perspective which is so valuable and effective in curing the worst disease of our times, ego- and ethno-centrism. In a work of this kind, in order to avoid confusing and misinforming the reader, fact must be explicitly distinguished from theory. To do this, the author must be very clear about and conscious of this himself and constantly and emphatically point it out to the reader. In most cases, Dr. Howells is particularly careful to do this.

The subject matter is divided into three logical parts. In Part I, evolution, its causes and effects, is remarkably simply and accurately discussed. However, the mechanics of evolution are omitted because the author says "they are not actually necessary here". I feel this omission is most unfortunate. A simple yet correct,

understandable explanation of this subject usually so incorrectly understood by the layman and non-biologically trained teacher would be most welcome. As a college teacher of physical anthropology for a great many years, I have found that perhaps upon no other subject taught in high school and in non-biological courses in college are students so confused and so inaccurately informed as upon this one — the mechanics of evolution. So I appeal to Dr. Howells to reconsider his statement that "they are not actually necessary here" and to correct this omission in his simple, direct, and capable style in the next printing by an appendix or some such means. In the rest of this section, man is dispassionately shown to be just one of the vertebrates, one of the mammals, one of the primates, one of the anthropoids, and, finally, how at last he is distinctive as an hominid. Part II is particularly valuable in assembling the material on fossil man up to date. It also deals with the origin of Homo sapiens which is of course theoretical, therefore controversial. The author clearly recognizes this by his statement "problems are almost all that fossil humanity has given us." Part III is devoted to the nature and possible origin of the present day races. He reveals that the races were probably in the process of separation while Homo sapiens was still evolving. He emphatically points out that "you must comprehend the nature of race in order to understand its history, but you also must understand its history to understand its nature". Yet he treats very inadequately the nature of race and writes at great length on the history of race drawing heavily from Carleton Coon's RACES OF EUROPE. This apparent inconsistency may be explained by the fact that the latter, being perhaps more complicated and controversial, is the less usually discussed aspect of race. He ends with a prophecy of man of the future. His inferences are reasonably built upon the evolutionary trends in the past, the morphology of man's closest animal relatives — the anthropoid apes — and the remains of fossil man.

As much of the subject matter of this book is one of interpretation, it is natural that I am not always in accord with the many inferences drawn and the hypotheses set forth. To point out specific instances of disagreement would be of no special interest or of any real value to the reader of this review.

MANKIND SO FAR meets a great need in presenting a biologically sound story of the nature and possible origin of man and the living races. It is particularly to be recommended to the layman, to the teacher who has specialized in other fields but whose special subject requires just the information which is so simply, entertainingly, and yet so accurately given in this book, and to the fundamentalist who still thinks that if man is an animal at all, he is most superior and advanced in every way and a finished product. It is also excellent as a text or reference for a survey or non-laboratory lecture course on the evolution of man.

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A RACIAL ANALYSIS OF THE ANCIENT GREEKS:

AN ESSAY ON THE USE OF MORPHOLOGICAL TYPES

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THIRTEEN FIGURES

In the following pages I propose to outline the racial history of Greece, to show how this history is illuminated through use of morphological types, and to allow this discussion to answer the question of the validity of such types. Elaborate analysis of a small sample of skulls is amply justified by the importance of clarifying the genetic makeup of the ancient Greeks, creators of the first civilization of Europe.

They were the first Europeans with enough strength and individuality to use the cultural wealth of the urban Near East without being overwhelmed by it. The Greeks, especially the Athenians, put together an unique culture in which grew the roots of almost every important element in our own society. Only in the fields of religion, law, mathematics, and such branches of material culture as dress, have any other people contributed more. As a result some knowledge of Greek history or literature is part of the background of every educated American or European. And myriads of studies in archeology, art, history, and linguistics have been undertaken to establish the greatness of the Greeks or to clarify the origins of their culture. But although speculation on the makeup and origins of the creators of this culture has flourished, no adequate outline of their racial history has yet been published, in spite of the work of such investigators as Virchow, Fürst, Breitinger, Koumaris, and Myres. Hence not only the Egyptians but also such peoples as the Eskimo or Australians are racially far better known than the Greeks. The present study will partly fill this gap in knowledge, and will show also how necessary to a full understanding of Greek history is a picture of Greek racial changes during the past 5 millennia.

Except for those few of the crania published by Virchow (1872, 1891, and 1893), which I was unable to remeasure, the material for this study

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was gathered in 1938 and 1939 [1], the greater part of my time bein spent in painstaking mending and restoration: for climatic and geo logical reasons skeletal material is as poorly preserved in Greece a anywhere in Europe, except for the rare skeletons submerged in un changing mud of wells. Thus only about a quarter of the material i in good condition.[2] Also the communal ossuary forms of burial i vogue at various periods result in loss of faces and other breakage, s that about one third of skulls totally lack faces.[3] Both these factor complicate sexing,[4] and together with inevitable archeological selectio of the toughest skulls they disturb both site sampling and sex ratios Thus the typeable skulls amount to 255 males, 132 females, and 2 children. No further explanation is needed for the dearth of females, which is the reason for concentrating on male crania in the presen study.[6] Data on the skeleton will also be omitted from this study.

The distribution of all skulls, including fragments, is given in table 1 They cover a relatively small geographical area centered on the isth mus of Corinth, and can safely be treated as a unit at all periods excep the beginning of the Early Iron Age, when the Cephallenians from th opposite, western, end of the Corinthian Gulf are treated as a separat group (Angel, '43).

As shown in table 1, the material is scattered chronologically over a total time span of about 4500 years, from the Neolithic to the Medieva periods of the archeologist and historian. In order to illuminate th racial changes which accompany historical developments during thi lapse of time I have adopted seven period subdivisions, separated fron each other according to statistical necessity and what I believe to b

[1] I worked in Greek museums and excavations from the end of 1937 to the spring of 1939 through the foresight and support of Dr. E. A. Hooton and Dr. G. H. Chase of Harvard Uni versity, and under the auspices of Harvard and of the American School of Classical Studies a Athens; with the assistance and encouragement of Dr. T. L. Shear, Dr. C. H. Morgan, Dr. W B. Dinsmoor, Mr. B. H Hill, Dr. C. W. Blegen, Dr. D. M. Robinson, Dr. S. Marinatos, and many other archeologists, as well as that of the curator of the Greek anthropological museum Dr. John Koumaris, to whom I am peculiarly indebted. For access to material in American museums I wish to thank Dr. T. D. Stewart and Dr. H. L. Shapiro. Travelling fellowship from Harvard supported the field work, and a grant from the Jefferson Medical College de frayed costs of publishing tables and drawings.

[2] Of 255 males, 25.49% are well preserved, 53.33% fair, and 21.18% in poor condition.

[3] Of 265 males, 40.00% are crania, 27.54% calvaria, 18.49% calvariae, 10.19% calvae, and 3.78% odd jaws and fragments.

[4] Sex criteria are objectively certain in only 69.53% of 256 males, though less than 3% of skulls seem of doubtful sex as far as they are preserved.

[5] In sites such as the American excavations at Athens and Corinth where I have been able to examine every skull excavated, the sex ratio seems about even, though more females than males are unrestorable.

[6] Full statistical data on females as well as males are given in Angel ('42 a), table XXXIV

narks of cultural change, and following the accepted subdivisions of he historian and archeologist. These are dated as follows. Neolithic before 3000 to ca. 2800 B.C.) and Early Helladic (ca. 2800–2000 B.C.) ıre taken together as the time of pre-Greek hoe-farming and local trade 'ollowing the first appearance of man in Greece so far proved. Middle Ielladic (ca. 2000–1400 B.C.) and Late Helladic I and II (1600–1400 3.C.) are combined to form the middle bronze age which the first Greek nvaders are assumed to have begun and during which the cultural ›uildup occurred to the Mycenaean or Late Helladic III period (ca. .400–1150 B.C.) of widespread trade, the flowering of bronze age civili- ation in Greece, when the Greeks outstripped the Minoans of Crete. The Submycenaean (starting ca. 1150, and earlier in Cephallenia), Protogeometric, Geometric, and a part of the Archaic periods (down to

T A B L E I

Geographical and chronological distribution of mainland Greek crania

Region	NEOLITHIC - E.H. ca.3000-2000 B.C.			M.H.-L.H. II ca.2000-1400			MYCENAEAN (L.H.III) a.1400-ca.1150			EARLY IRON AGE a.1200-650			CLASSIC 650-150 B.C.			ROMAN 150 B.C.-450 A.D.			BYZANTINE a.450-1300 A.D.			TOTAL SERIES ca.4500 years		
	M.	F.	C.	M.	F.	C.	M.	F.	C.	M.	F.	C.	M.	F.	C.	M.	F.	C.	M.	F.	C.	M.	F.	C.
Macedonia	1												4	5								5	5	
Thessaly	1			1				2														2	2	
Boeotia						1		1					11	5		2	1		3			16	7	1
Attica	14	8	2	1			13	7	1	21	13	3	18	6	1	5	7	1	1	1		73	42	8
Corinthia	12	9	9							3	1	1	26	12	2	13	6	1	27	9	7	81	37	20
Argolis				21	13	2	28	17		3	2					1	2					53	34	2
Arcadia	1																					1		
Acarnania	2																					2		
Cephallenia										30	12											30	12	
Leukas	(4)																					(4)		
Eleusis																								
undateable				(1??)						(4	3??)											(5??	3??)	
Total	35	17	11	23	13	3	41	27	1	57	28	4	59	28	3	21	16	2	31	10	7	272	142	31

50 B.C.) are lumped together as the Early Iron Age period of Dorian nd other invasions, local isolation, piracy, and gradual cultural rise o the Classical and early Hellenistic phase (650–146 B.C.) of extensive rade and colonisation, commercial immigrations, and high cultural chievements. There follow the Roman occupation period (150 B.C. to a. 450 A.D., including late Hellenistic and Late Roman or earliest Byzantine) and the Byzantine and Medieval periods (down to ca. 1300 A.D.) of irregularly quiescent decline together with irruptions of Visi- goths, Huns, Vandals, Avars, Slavs, Franks, Aragonese, Venetians, nd Norse. It is obvious at once from tables 1 and 8 that these periods veraging over 600 years each are too long for the small samples vailable, especially considering the relative brevity of the Mycenaean period compared with the elongated phases at beginning and end of he sequence.[7]

[7] But there are only about 17 ancient skulls dating before ca. 2400 B.C. and after 1100 A.D.

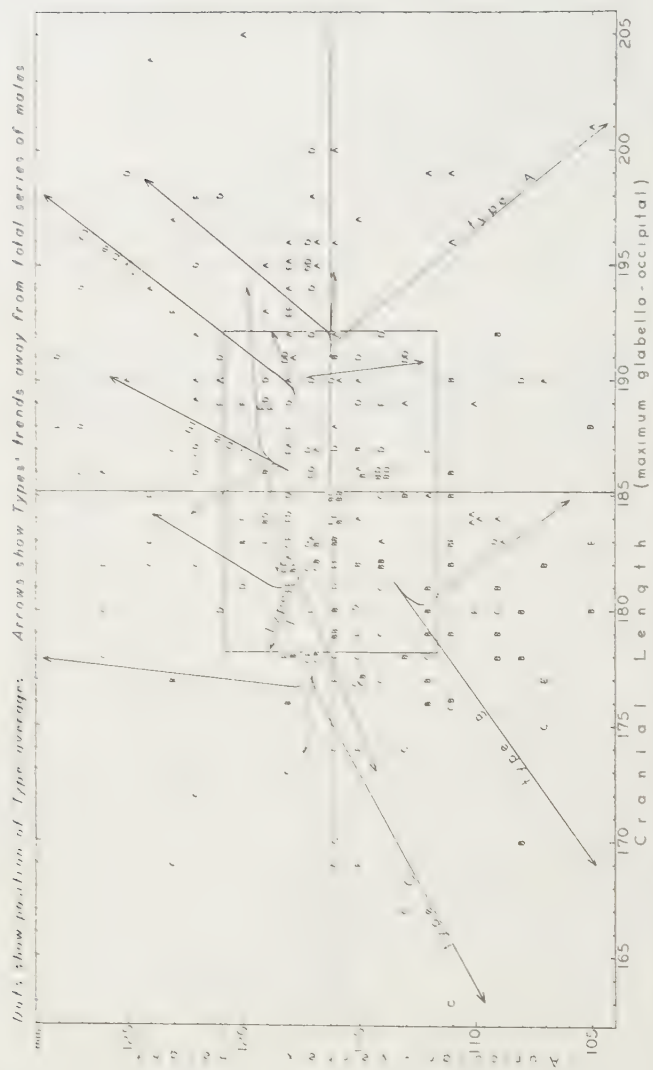
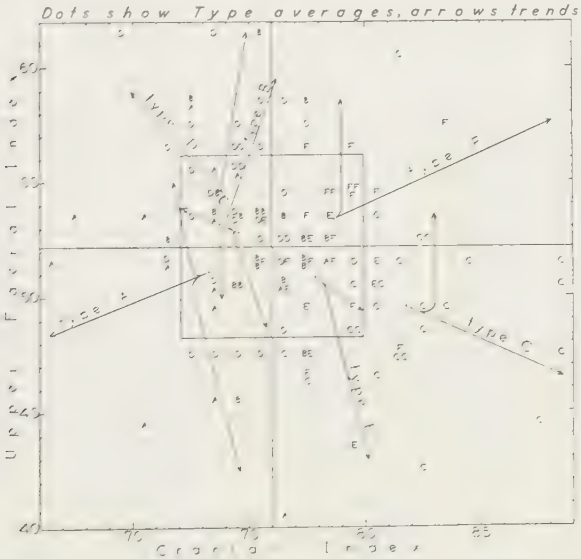


Fig. 1 Scattergram of cranial length and auricular height of total series of males to show relative position of individual skulls assigned to the six morphological types and to clarify the degree of metrical overlap between types. The small rectangle is formed by perpendicular lines cutting the coordinates at a distance of $1 \times \sigma$ from the means. No regression lines have been worked out.

'he material's condition varies considerably from period to period. ania of Early Helladic, Mycenaean, and Cephallenian origin come m the collective burials dominant in these cultural groups and usually x faces wholly or partially. And material from the prehistoric iods in general is less well preserved than that of later date. No ection of modern Greek skulls is available, since the recent series blished by Weisbach (1881) is of Anatolian and European Turkish venance, with only a few individual skulls from mainland Greece. ave therefore used a small group of living Greeks from the region und the Corinthian isthmus to predict what the probable cranial asurements of modern Greeks may be.

MORPHOLOGICAL TYPES

t is my hypothesis that really useful and dynamic description of h small samples as are available for the above sequence of culture iods is possible only through the use of morphological types, chosen m the total series and then plotted according to their frequencies at erent periods and related to the average measurements of the



g. 2 Scattergram of cranial index and upper facial index to show tendencies toward type ping and overlap. Coordinates are drawn at the level of the means of the total series. regression lines have not been worked out. Because of burial conditions in Early Bronze and naean times especially more dolichocrane than brachycrane skulls lack measurable faces.

TABLE II a

Measurements, indices, variability constants of Greek male and female total series

Character	MALES Mean	p.e.	N	Range	σ	V	FEMALES Mean	p.e.	N	DEFINITIONS Bio- metric	Martin
Capacity	1438.52		*				1311.05		*	C	38d
Horiz.circumf.	518.38	.73	199	484-560	15.34	2.79	499.49	.82	95	U	23a
Sagittal arc	374.46	.65	179	336-410	12.84	3.45	362.68	.79	82	S	25
Frontal arc	127.40	.33	161	110-150	6.14	4.82	124.02	.41	87	S_1	26
Parietal arc	128.48	.40	162	108-153	7.56	5.88	124.28	.50	92	S_2	27
Occipital arc	118.96	.37	134	103-136	6.36	5.35	113.68	.59	66	S_3	28
Transverse arc	309.42	.54	185	284-343	10.86	3.51	299.22	.74	86	Q'	24
Length	185.16	.31	238	163-205	6.98	3.77	176.34	.33	130	L	1
Breadth	140.31	.25	243	121-154	5.79	4.13	136.32	.34	130	B	8
Basion-brg. ht.	133.19	.28	177	118-146	5.61	4.21	129.02	.36	87	H'	17
Auricular ht.	116.24	.20	234	105-128	4.61	3.97	112.64	.28	116	(OH	21)
Min.frontal b.	96.36	.22	213	86-113	4.80	4.98	92.95	.23	101	B'	9
Max.frontal B.	118.18	.34	136	101-136	5.96	5.04	113.97	.42	71	B''	10
Frontal chord	112.86	.26	146	100-131	4.72	4.19	107.68	.34	81	S_1'	29
Parietal chord	115.30	.33	150	100-128	5.96	5.17	111.44	.42	85	S_2'	30
Occipital "	98.28	.34	121	83-121	5.62	5.72	93.84	.39	61	S_3'	31
Basion-nas.l.	100.52	.26	160	89-112	4.95	4.92	95.89	.32	76	LB	5
B-prosthion l.	95.75	.32	125	85-109	5.23	5.46	91.22	.44	58	(GL)	40
Frontal angle	50.41	.18	165	39- 61	3.49		50.71	.26	78		32(1a)
Facial angle	87.28	.22	128	79- 98	3.68		*86.25	.38	60	(PA)	72
Midfacial angle	93.20	.22	130	83-103	3.64		93.82	.34	57		(73)
Alveolar angle	69.10	.42	127	59- 96	7.00		66.64	.52	58		(74)
Nasalia angle	54.74	.43	109	42- 75	6.64		55.68	.75	37		75
Bizygomatic br.	131.36	.39	138	118-149	6.86	5.22	122.47	.46	66	J	45
Bigonial br.	99.70	.56	81	81-117	7.44	7.46	92.90	.49	44	w_2	66
Face height	113.89	.55	88	92-136	7.68	6.75	108.60	.73	39	GH	47
Upper face ht.	68.38	.27	144	52- 81	4.88	7.14	65.15	.32	68	G'H	48
Nose height	50.18	.19	152	39- 59	3.50	6.97	48.25	.22	70	NH	55
Nose breadth	24.54	.10	153	20- 29	1.89	7.70	23.39	.15	66	NB	54
Upper nasalia	12.29	.12	192	5- 21	2.37	18.28	12.04	.17	85		57(2)
Lower nasalia	17.03	.14	100	13- 24	2.10	12.33	16.40	.19	40		57(3)
Left orbit ht.	32.52	.13	144	24- 39	2.30	7.07	33.12	.21	67	O_2L	52
Right orbit ht.	32.68	.13	145	27- 39	2.28	6.98	32.94	.21	63	O_2R	52
Left orbit br.	39.21	.10	143	36- 44	1.82	4.64	38.00	.17	61	O'_1L	51a
Right orbit br.	39.50	.10	142	35- 43	1.84	4.66	38.13	.15	62	O'_1R	51a
Interorbital b.	21.57	.10	185	16- 29	2.10	9.74	21.02	.16	81	DC	49a
Biorbital br.	98.40	.22	151	89-108	3.98	4.04	94.31	.29	59	(IOW)	44
Ext.palate l.	53.41	.17	134	43- 60	2.97	5.56	50.49	.21	59	G_1'	60
Ext.palate br.	63.32	.23	119	55- 72	3.71	5.86	58.64	.32	59	EB	61
Symphysis ht.	31.55	.22	116	24- 39	3.47	11.00	29.04	.29	54	h'	69
Jaw length	102.86	.64	61	90-117	7.38	7.17	97.66	.65	38	ml	68(1)
Bicondylar br.	121.88	.65	58	103-136	7.34	6.02	115.86	.75	37	w_1	65
Min.ramus br.	31.47	.15	110	26- 38	2.38	7.56	30.18	.25	51	rb'	71a
Jaw angle	123.40	.44	92	104-141	6.26		*126.10	.46	49	mA	79
Cranial index	75.99	.17	234	66- 88	3.95		*77.49	.26	126	Br./ L.	
Length-ht."	73.22	.16	177	59- 81	3.48		73.33	.22	86	B-b.h/L.	
Length-aur.ht.	62.85	.14	223	52- 72	3.07		*63.82	.17	111	Au.h./L.	
Breadth-ht.	94.89	.25	176	82-109	4.90		94.95	.37	84	B-b.h/Br.	
Breadth-aur.ht.	82.93	.17	225	73- 95	3.79		82.60	.26	111	Au.h./Br.	
Fronto-parietal	68.61	.17	203	60- 79	3.60		68.20	.22	97	Mn.fr/Br.	
Cranio-facial	92.81	.22	137	79-103	3.87		*90.45	.36	65	Bz.br/Br.	
Zygo-frontal	73.34	.23	132	63- 84	3.90		*75.82	.31	60	Mn.fr/Bz.br	
Fronto-gonial	104.34	.60	69	85-118	7.38		101.26	.61	33	Bg.br/Mn.fr	
Zygo-gonial	76.53	.40	69	65- 87	4.98		75.53	.52	29	Bg.br/Bz.br	
Facial index	87.05	.49	77	71-102	6.36		89.20	.52	33	Fac.h/Bz.br	
Upper facial	52.19	.25	120	40- 61	3.98		53.47	.26	57	U.f.h/Bz.br	
Nasal index	49.00	.27	146	37- 66	4.79		48.71	.32	66	N.br/N.ht	
Left orbital	83.02	.34	137	63-102	5.98		*87.40	.51	58	Or.ht/Or.br	
Interorbital	21.97	.11	139	16- 27	1.91		22.32	.21	53	Intor/Biobr	
Ext. paletal	118.05	.45	111	103-136	7.00		117.02	.76	50	E.p.b/E.p.l	
Stature	162.19 cm.		61	148-175			153.35 cm.		43		
Variability:											
Mean V vault	4.49		177.4	(16 measurements)			3.96		90.4		
Mean V face	6.74		124.5	(16 measurements)			6.28		57.9		
Mean σ indices	4.73		149.1	(15 indices)			4.29		71.0		
Mean σ angles	5.12		125.2	(6 angles)			4.82		56.5		
Sigma Ratio	111.15 (39)		150.31				(101.06)		68.9	(estimate)	
Age at death	39.9 years		249				31.35 years		134		

TABLE IIb

Morphological observation percentages on total series of males from mainland Greece

Observation	%
Age at death (249)	
subadult	.80
young adult	39.37
middle aged	54.16
old adult	5.22
Asymmetry (211)	
trace	41.71
slight	33.91
medium	17.53
pronounced	.95
Headform (237)	
ellipsoid	18.99
ovoid	35.44
pentagonoid	29.11
rhomboid	4.64
sphenoid	4.22
tyrsoid	5.49
spheroid	2.11
Browridge size (225)	
small	8.00
medium	37.33
large	51.11
very large	3.56
Forehead ht. (234)	
very low	3.42
low	36.32
medium	49.15
high	9.83
very high	1.28
Forehead slope (232)	
none	8.62
slight	30.61
medium	45.69
marked	14.65
very marked	.43
Metopic suture (234)	
none	88.03
trace	9.40
complete	2.57
Postorb.constr.(226)	
slight	19.47
medium	69.03
pronounced	11.50
Frontal bosses (231)	
small	33.33
medium	62.34
large	4.33
Parietal bosses(238)	
small	35.29
medium	54.62
large	10.09
Sagittal crest (235)	
slight	34.89
medium	52.34
marked	10.64
very marked	2.13
Temporal bulge (236)	
flat	6.36
slight	49.58
medium	39.40
pronounced	4.66
Mastoid size (230)	
small	1.74
medium	53.48
large	44.78

Observation	%
Occiput curve (232)	
none	.43
slight	18.10
medium	61.64
pronounced	19.83
Torus size (223)	
none	6.28
small	32.18
medium	58.02
pronounced	8.52
Lambdoid flatng(235)	
none	37.02
slight	45.53
medium	16.60
pronounced	.85
Basion elevation(172)	
low	15.12
medium	59.88
high	25.00
Occ.condyles ht(173)	
low	28.33
medium	49.13
high	22.54
Pharyngeal fossa(163)	
none	68.71
medium	22.09
deep	9.20
Glenoid fossa (219)	
shallow	6.85
medium	41.55
deep	51.60
Postglenoid pr.(224)	
small	37.50
medium	49.11
large	13.39
Auditory meatus(228)	
round	11.84
oval	49.56
elliptical	37.72
slit	.88
Orbit form (183)	
oblong	38.80
square	9.84
rhomboid	43.16
ellipse	8.20
Orbit slope (184)	
none	4.35
slight	43.48
medium	47.28
pronounced	4.89
Cheekbones (170)	
small	15.88
medium	66.47
large	17.65
Lateral project(171)	
slight	25.73
medium	59.06
marked	15.21
Anterior projection (169)	
slight	17.16
medium	75.15
marked	7.69

Observation	%
Nasion depr. (218)	
none	1.38
slight	27.52
medium	63.30
deep	7.80
Nose root ht. (205)	
low	11.22
medium	56.10
high	31.70
very high	.98
Root breadth (206)	
v.narrow	2.91
narrow	29.61
medium	48.06
wide	18.93
very wide	.49
Bridge height (151)	
very low	.66
medium	37.09
high	55.63
very high	6.62
Bridge breadth (151)	
narrow	32.45
medium	51.66
wide	15.89
Nose profile (140)	
Straight	22.14
concave	39.28
conc-convex	37.15
convex	1.43
"Classic profile" (149)	
absent	76.51
medium	22.82
pronounced	.67
Nasal sills (157)	
none	4.46
dull	16.56
medium	47.77
sharp	31.21
Nasal spine (141)	
none	2.84
small	31.91
medium	46.81
large	18.44
Palate shape (152)	
parabolic	46.71
hyperbolic	9.21
elliptical	25.00
small U	12.50
large U	6.58
Palate height (152)	
low	14.38
medium	48.37
high	33.98
very high	3.27
Alveolar prognathism	
palate(146)	jaw(114)
none 65.07	35.96
slight 26.03	48.25
medium 8.90	14.91
marked 0	.88
Chin projection(121)	
negative	1.65
neutral	15.71
slight	38.84
medium	37.19
pronounced	6.61

Observation	%
Chin type (119)	
median	53.78
bilateral	46.22
Pterygoid att.(108)	
weak	2.78
medium	44.44
marked	47.22
very marked	5.56
Gonia eversion(112)	
none	24.11
slight	38.39
medium	31.25
pronounced	6.25
Type of bite (111)	
edge	43.24
slight over	44.15
medium over	11.71
pronounced	.90
Crowding (172)	
none	93.02
medium	6.98
Teeth eruption(182)	
incomplete	1.65
complete	75.27
M3 supprd.	23.08
Number molar cusps both sexes(103-179)	
upper M1	4.92
upper M2	3.71
upper M3	3.10
lower M1	4.95
lower M2	4.44
lower M3	4.21
Teeth quality (167)	
very poor	1.20
poor	2.39
medium	22.75
good	49.71
excellent	23.95
Teeth wear (169)	
none	1.18
slight	23.08
medium	45.56
marked	26.63
very marked	3.55
Pyorrhea (173)	
absent	38.72
present	61.28
Shovel incisors(67)	
absent	38.81
slight	41.79
medium	19.40
Teeth loss (107)	
0	35.52
1 - 4	33.64
5 - 8	15.90
9 - 16	8.40
17 - x	6.54
Abscesses (107)	
0	50.47
1 - 3	49.53
Teeth caries (106)	
0	55.66
1 - 4	41.51
5 - 8	2.83
9 - x	0

Note : the standard for all non-specific morphological observations is the modern adult male northwest European. Since the above percentage frequencies form the basis for estimating the morphological deviations of the six types from the total series, Table IIa may be referred to in interpreting Table IV. Crania alone were used in calculating Teeth loss before death, Alveolar abscesses, and Teeth caries. Note also that males and females were pooled for calculating the mean number of molar cusps.

periods.[8] To find out for himself the value of this method, which wa first worked out by Hooton ('30), the reader may study carefull tables 8 and 9, correlate them with the known population shifts an environmental changes in Greece to gain some picture of the force responsible for racial changes there and of the nature of these racia changes, and then compare his results with those reached through us of types.

Because of scattered museum distribution of the material the onl method of type selection available (based on Hooton, '30, pp. 185–186 was to mount from four to six carefully standardised photographs o each skull all enlarged to exact scale on a single card, so that simu taneous comparison of all norms of each skull with the others wa possible. Repeated sorting and grouping together of those skulls whic seemed most nearly identical allowed easy assembly of twenty-thre "mutual resemblance subgroups" of ten to twelve skulls each.[9] By a extension of the same process with minimal use of measurements thes subgroups were combined into six morphological types. These sho real approximation to the impressionistic typing done hastily in th field.[10] They are obvious genetic composites, and they overlap one a other metrically as shown in figures 1 and 2 just like any pot-pourri o geographical races.

But the success of selection of the six types is shown by their clea cut separation from the total series of Greek males illustrated by fig ures 3 to 10, and by tables 2, 3, and 4 containing the basic data fro which the sketches were made. The types' validity will be clear in thei homogeneity, greater than that of either the total series or the averag period group, the average Sigma Ratios (Howells, '41, pp. 146–147 being 98.95 contrasted with 111.15 and 107.01 respectively for type

[8] Up to 39 measurements and 119 observations were made on each skull, depending on it completeness. I used the technique of the anthropology laboratory of the Peabody Museu under Dr. E. A. Hooton. Measurements are precisely defined by R. Martin's ('28) number and by the Biometric School's symbols listed in table 2, except for those in parentheses auricular height is taken to vertex, and a point on the upper surface of the nasal spine i substituted for Martin's nasospinale for facial angles (Angel, '43, p. 231).

[9] In this process I was assisted by sortings by Prof. E. A. Hooton, and by critical comment from Drs. C. S. Coon, C. C. Seltzer, A. Brues, J. B. Birdsell, S. L. Washburn, C. K. M. Kluck hohn, and other anthropologists.

[10] Field typing was suggested in the first place not so much by previous speculations or b the archeologists' requests for useful descriptions of the Dorians or other contributors to th Greek people as by two subjective impressions: first, that certain sites had been inhabited b a bewilderingly heterogeneous population (compare Koumaris, '31, and Breitinger, '39); sec ond, that at some sites "family" resemblances could be detected in spite of heterogeneit (compare Fürst in Wace, '32, and Angel, '39), so that certain recurrent trait combinatio seemed to give subtle similarity to groups millennia apart.

ontrasted with total series and period groups; and in their metric pproximations to non-Greek series representing recognized "racial" rends within the white race, as seen in figures 11 and 12, and in table compared with table 5. The types' usefulness will be shown in the ccuracy of their predictions of average measurements of period samples, as shown in tables 7, 8, and 9, and in the vividness of the picture f population changes which they give in figure 13 and table 6.

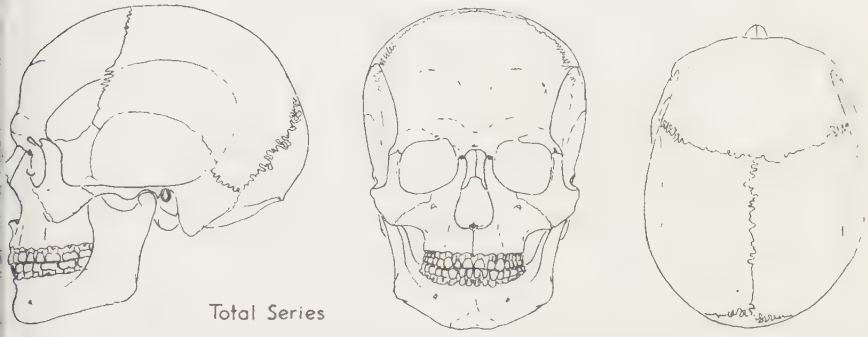


Fig. 3 Sketch drawing of the average ancient Greek male, based accurately on measurements, morphological observation percentages, and photographs. Exact following of measurements creates a diagraphic or flat perspective, lacking foreshortening.

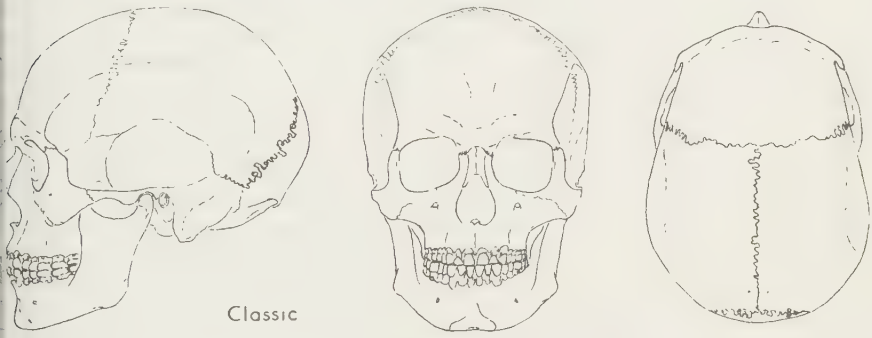


Fig. 4 The average Greek of the Classical period.

So great is the phaenotypic racial continuity of the Greek people in ncient times (and probably down to the present day) that the average ncient Greek male defined by the total series in table 2 may well stand or ancient Greece as a whole as well as for the standard of comparison or the six types.

The average ancient Greek has a skull vault of average size and edian proportions tending toward long-headedness, with relatively

long parietals. Well-marked browridges set off a relatively low, broad smooth forehead without much slope. The well-filled and smooth parietals are rounded except on top, but show rather flat sidewalls, and in profile a consistent though slight flattening of the obelion-lambda region leads down to the evenly rounded occipital, whose nuchal muscle markings are unimpressive in contrast with the mastoids and supra-mastoid crests. The skull base shows relatively sharply cut relief in contrast to the vault, with high projection of basion, deep glenoid fossa, strong pterygoid plates. The face of the average ancient Greek is much more characteristic because of its striking lowness, especially in the subnasal section, accentuated by broad jowls. Low, angular, and relatively level orbits are linked with robust and uncompressed cheekbones. The mesorrhine nose is capacious, with unimpressive spine but high and narrow bony root and bridge which combine with a weak nasion depression to give some degree of forehead-nose profile continuity in 23.5% of cases. The mouth region is rarely protrusive and the face is typically orthognathous. A broad and high-arched palate corresponds to a broad but shallow jaw with robust pterygoid and masseter impressions and a chin not notably protrusive by modern northwest European standards. The most striking feature of the face, its excessive breadth at the gonial angles, gives it a square outline in front view. Teeth are good, with medium wear, little or no crowding, relatively few caries or abscesses, a frequent labiodont bite, slight shovel incisors, and some tendency toward suppression and reduction of the third molar. These are the salient features of ancient Greeks by modern northwest European or American standards.[11]

The sex differences shown in table 2 a are about average for Europeans both morphologically and metrically (compare Borovansky, '36), the size difference being greater than among Palestinians or Egyptians and less than among north Europeans (Risdon, '39, Schreiner, '39). In table 2a significance is indicated only for features more or less unaffected by the size difference between the sexes. Statistically significant female leptoprosopy is perhaps unexpected, but fits logically with the greater facial constriction, large high orbits, narrower mouth and greater prognathism of the females.

Female variability is 90.92% of the colossal variability of the male total series, and is thus somewhat lower than expected (compare

[11] Compared to medieval Norwegians from Oslo (Schreiner, '39), representing north Europeans, ancient Greeks show in addition to their generally smaller size: relatively higher vault, longer parietals; relatively smaller, lower, narrower-jowled, and more orthognathous face with relatively broader nose, lower orbits, and shallower jaw with less square angles.

chreiner, '39, pp. 123–129), probably because of the smaller sample f females. From the opposite point of view the male variability may e relatively raised because skulls of more male than female invaders nto Greece may conceivably be included in the sample. Certainly the igh male variability can be shown to reflect a great heterogeneity of ype, as the type descriptions will make clear. And though the types are

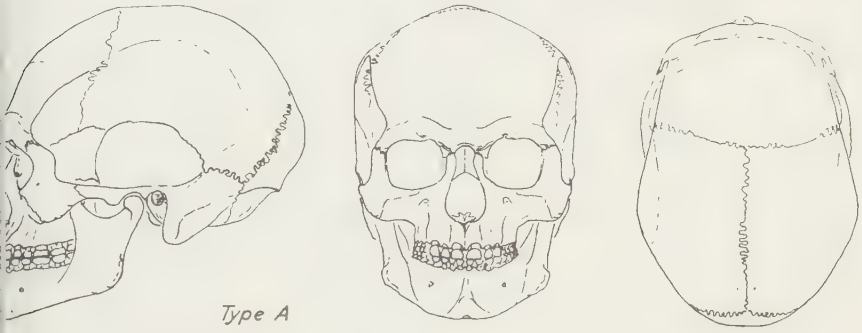


Fig. 5 The Basic White type (type A), based on measurements in table 3, on observations, d on photographs, with statistically significant morphological distinctions from the total ies (see fig. 3) slightly exaggerated for emphasis.

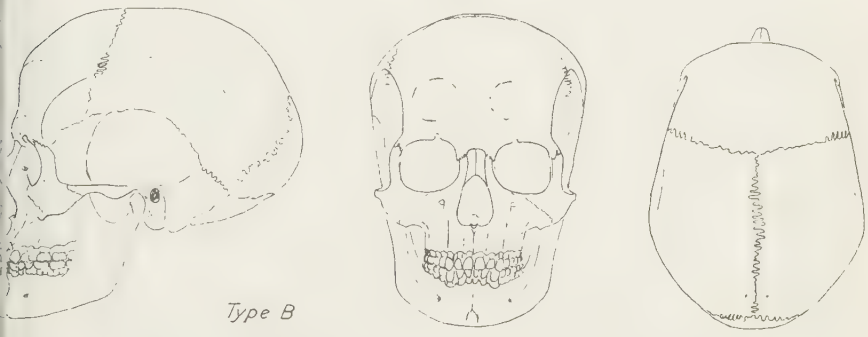


Fig. 6 The Classic Mediterranean (type B), emphasizing gracility.

most as clear among females as among males, the smaller female ries makes it much harder to test them statistically and female crania e omitted from this study.

Since the various characteristics of each type are fully set out in bles 3–5 and figures 3–12, no over-elaborate validation of each type necessary. But a short sketch of each type and some mention of the ends of variation within each type are both necessary for an under-anding of the sequence of racial changes in Greece as interpreted

here. The types are lettered in the order of their frequency of occu rence from A through F, and the sub-trends within each type have be numbered as seen in figure 13. It may be easier for the reader to sti to their names and ignore the letters and numbers. The types will n be described in the order of their frequency but in the order of the morphological resemblances to one another: A, B, D, F, E, C.

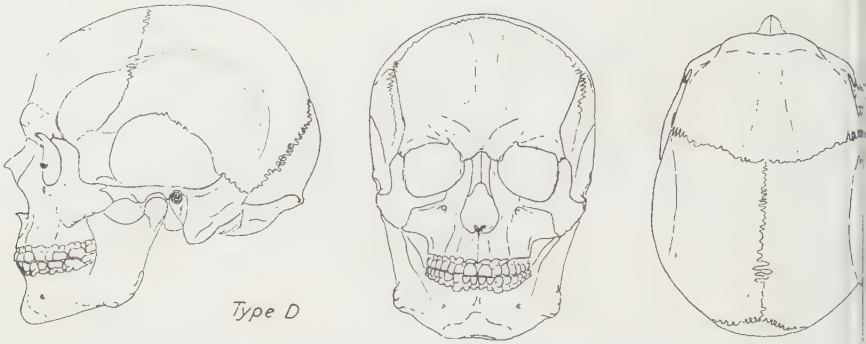


Fig. 7 The Nordic-Iranian (type D). Note rectangular face.

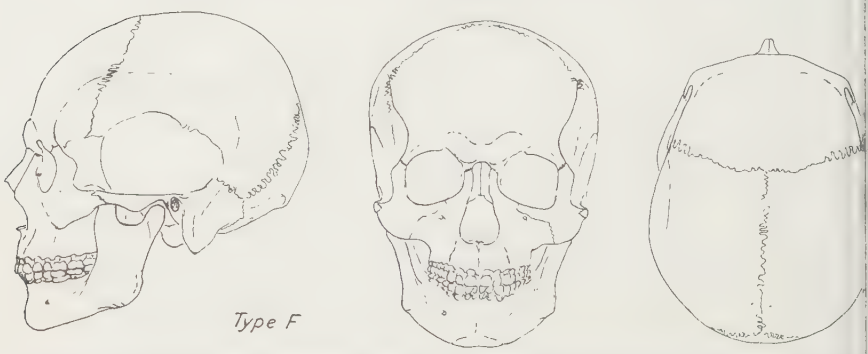


Fig. 8 The Dinaric-Mediterranean (type F) to show contrasting Alpinoid traits combin with dolichocrane features as seen in figures 5, 6, and 7. Note elongated hexagonal face.

Type A is called Basic White because it seems to me a little clos to a Galley Hill or Combe Capelle form than to linear-faced, more le torrhine Atlanto-Mediterranean or Eurafrican varieties of the whi race. The long and rather low skull is large and rugged, with a surfa made up of flat planes whose angular junctions give an ill-filled appea ance and a pentagonoid norma verticalis. Heavy browridges proje below the low, receding, and relatively broad forehead, and emphasi its postorbital constriction. Angularity shows in the gabled vault and

he flattened lambdoid region combined with markedly curved occipital one. The face is relatively low, though the total face height is probably to 5 mm. lower than a larger sample would show, and the jowl breadth s striking. Rectangular orbits bounded by robust cheekbones, a short ose marked by straight nasal bones deeply recessed at nasion and by veak spine and dull sills, a well-squared palate, strong teeth, and a

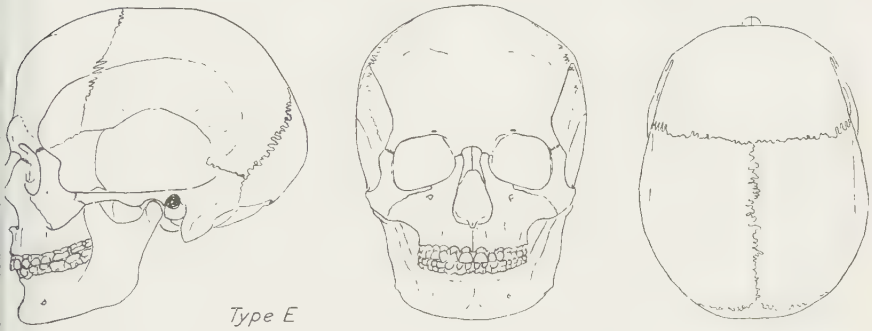


Fig. 9 The Mixed Alpine (type E), to show virtually Alpine morphology combined with bsolutely long skull vault.

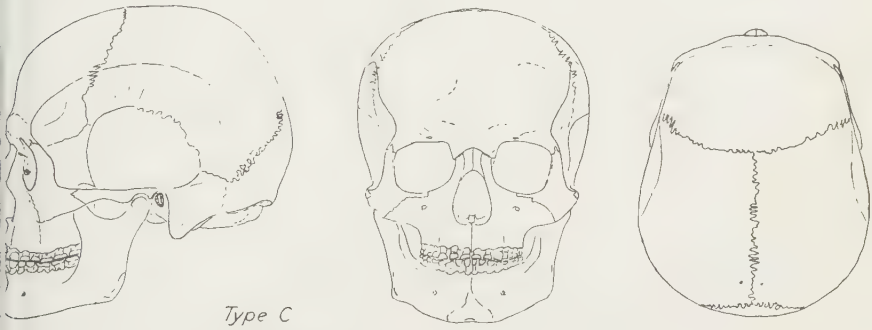


Fig. 10 The Alpine (type C), round-headed and low-faced.

obust jaw with fairly deep and strong chin all give the face a robusticity which approaches coarseness.

The Basic White type is definitely composite [12] as its slightly raised nean variability (Sigma Ratio) indicates, excess variability being con-

[12] It includes five of the original "mutual resemblance subgroups": A 1, the linear Megalithic end toward a longer, higher, more compressed, ill-filled, and gabled vault, with high, narrow-osed, long-jawed face; A 2, a cruder version of this; A 3 and A 5, respectively more rounded nd more angular central subgroups of Basic White; and A 4, an unusually low-headed and quat-faced variant, chaemeconch, chaemerrhine, with flat vertex, protruding occiput, and ometimes a high-arched bony nose.

fined to vertical dimensions of the vault and face, palate breadth, th affected indices, and the facial angles. With the present sample Basi White compositeness is unavoidable, and though the type is sharpl set apart from the total series its comparisons with outside series ar somewhat weakened, partly because these have to be chosen to repre sent the long-faced as well as the disharmonic, "Cro-Magnon", var ants of Eurafrican — Megalithic — Atlanto-Mediterranean trends i the white race.

In spite of this, the Basic White type's close similarities to Siculan (Giuffrida-Ruggeri, '01, '05) shown in figure 11, and probably also t Chalcolithic Palestinians from Megiddo (Hrdlička, '38) establish it validity, which is supported by adequate similarities with Chalcolithi Sardinians (Sergi, '07) and with Neolithic type British (Morant, '26 especially when virtual identities between individual skulls and th compositeness of Morant's series are considered. But both Sardinian and Neolithic British have narrower noses than Greek Basic Whites Comparisons with the non-brachycrane segment of the Swedish Ne lithic sample (Coon, '39, p. 659, table 18, after Retzius, '00, and Fürs '12), noted also by Fürst ('30), and with third millennium B.C. sout Mesopotamians (Keith, '27, Buxton, '24, Buxton and Rice, '31, an Penniman, '34) are both poor because of the high vaults and hig linear, faces of these groups, resulting plausibly from "Corded Nordic and "Iranian" influence respectively in Sweden and in Sumeria. Th breadth of these comparisons stresses the plausible geographic conti uity of a Megalithic-Basic White type from the Levant via Spain t Great Britain, with further extensions at either end (Coon, '39, p. 128 This indicates for Greek Basic Whites a maritime origin perhap eventually from the coast between southern Anatolia and souther Palestine (Angel, '43, pp. 252–253), though present ignorance of th mesolithic population just east of the Balkans (compare Coon, '39, p 68) may obscure a secondary source for a section of Basic Whites.

Type B, the paedomorphic Classic Mediterranean type of Serg ('01), is notable for its small size and gracility. The barely dolichocran vault is small-based, with a relatively low, vertical, and narrow fore head, and large parietal bosses which emphasize pentagonoid outline in both normae verticalis and occipitalis. The parietals are long, th occiput is sharply bent and projecting above unimpressive nucha muscle ridges, and the basion region is prominent. The narrow, lepto prosopic, face approaches an inverted triangle outline. Square an relatively horizontal orbits are enclosed delicately by small and com pressed cheekbones, and squeeze a narrow nose with low root, relativel

smooth nasion region, and weak nasal spine. A laterally pinched mouth region definitely shows a slight trend toward prognathism, and fits the weak and compressed jaw whose neat pointed chin is shallow. The effect of weakness is increased by combination of a definite overbite with the alveolar prognathism, apparently correlated also with a subnormal degree of teeth wear. In spite of its gracility the Mediterranean type does not include wrongly sexed female skulls: gracile males are common in modern Mediterranean populations.

The Classic Mediterranean type is homogeneous,[13] though its small size tends to overdepress the Sigma Ratio and the Vs show excess variability in vault height, orbit height, and chin height.

The type is strikingly similar to ancient Libyans (Derry, '27) and to modern Sicilians (Morant, '28, after Mondio, 1897). Upper Egyptian Badarians (Morant, '35, after Stoessiger and Derry) differ more, chiefly in their extreme narrowness, greater vault height, longer frontal bone, wider nose and interorbital space, and deeper and narrower jaw with wider ramus, epitomizing the uniform differences between Egyptian and European Mediterranean groups. Modern Spaniards (d'Aranzadi and Hoyos Sainz, '13) are slightly larger-skulled and are longer-faced than the Greek Mediterranean type. But some of the later, less adequately measured, series from Dynastic Upper Egypt (Morant, '25, after Broca, Chantre, and Thomson and MacIver) appear closer. These comparisons suggest a North African and Egyptian origin for the Classic Mediterranean type in Greece, but should not obscure the fact that in most places both gracile and rugged varieties of Mediterranean are associated, in varying proportions.

For this reason a comparison with other groups of a composite "Mediterranean" series made up of type A plus B is logical. Here Lower Egyptians of dynasties XXVI–XXX (Pearson and Davin, '24, Martin, '36) are too mesocranic and too high-faced for close comparison, and even a south Palestinian Iron Age population from Lachish (Tell Duweir) containing a respectable proportion of Upper Egyptian colonists (Risdon, '39) is not strikingly similar to the Greek composite Mediterraneans. But Minoan Cretans (Duckworth, '13, von Luschan, '13) show a reasonably close resemblance which a checking of Duckworth's mutually discrepant skull heights on a better sample might make more striking. This Minoan similarity extends to the low face characteristic in Greece (compare Angel, '43, p. 251), and hence must

[13] Variants B 1, 2, 3 are the ovoid, angular, ellipsoid vault trends noted by Sergi, and B 4 is a more linear variant.

T A B L E

Measurements, indices, variability ratings of six male morphological types for

Character	TYPE A Basic White Mean	p.e.	N	TYPE B Classic Mediterranean Mean	p.e.	N	TYPE D Nordic-Iranian Mean	p.e.	N
Calculated capacity	1467.86		*	1354.41		*	1476.32		*
Horizontal circumference	*525.73	1.33	45	*506.88	1.11	41	*525.92	1.36	39
Sagittal arc	*381.24	1.30	35	*366.67	1.10	43	*381.58	1.13	36
Frontal arc	*129.50	.76	32	*123.41	.55	33	123.29	.54	39
Parietal arc	128.98	.76	36	129.00	.94	32	129.61	.96	36
Occipital arc	120.29	.88	27	116.06	.56	27	*123.19	.70	32
Transverse arc	307.15	1.12	39	*301.95	.79	40	*312.57	1.02	37
Cranial length	*191.07	.49	56	*181.83	.40	54	*189.16	.43	44
Cranial breadth	130.54	.45	57	*135.29	.38	58	140.30	.49	43
Basion-bregma height	133.19	.61	36	131.95	.60	43	*135.03	.62	36
Auricular height	116.22	.46	50	*113.52	.34	56	117.64	.41	45
Minimum frontal breadth	97.28	.39	43	*93.23	.37	47	*97.73	.45	45
Maximum frontal breadth	117.64	.69	28	*114.13	.55	27	118.14	.64	33
Frontal chord	*114.17	.54	30	*109.12	.41	29	113.83	.47	36
Parietal chord	116.56	.59	36	115.21	.72	28	116.62	.80	33
Occipital chord	99.19	.92	26	*96.33	.70	24	*101.46	.54	27
Basion-nasion length	102.47	.55	32	*98.02	.44	41	102.67	.58	34
Basion-prostalon length	98.87	.91	16	*93.79	.57	28	*97.36	.56	33
Frontal angle	50.00	.38	34	50.73	.31	37	49.11	.42	35
Facial profile angle	86.37	.67	16	*86.07	.56	27	*86.09	.34	32
Midfacial angle	93.61	.54	18	92.94	.54	27	92.30	.36	32
Alveolar angle	66.90	1.33	15	67.69	.81	27	69.31	.69	32
Nasalia profile angle	54.50	1.27	17	55.05	.90	22	*51.26	.66	26
Bizygomatic breadth	132.52	.76	21	*125.46	.56	24	131.55	.55	33
Bigonial breadth	102.78	1.20	7	93.52	1.48	11	103.90	1.01	20
Total face height	109.17	2.46	6	112.38	1.41	11	*118.12	.95	26
Upper face height	67.05	.83	19	*66.67	.38	30	*71.08	.53	27
Nose height	*48.92	.48	22	49.21	.33	33	*51.97	.42	36
Nose breadth	24.95	.25	22	23.80	.17	31	24.78	.20	37
Upper nasalia breadth	12.51	.22	39	12.00	.29	44	12.22	.27	37
Lower nasalia breadth	18.11	.58	9	16.43	.26	23	17.09	.30	22
Left orbit height	32.24	.31	25	32.16	.28	31	32.79	.24	34
Right orbit height	32.19	.37	21	32.41	.25	34	33.11	.24	35
Left orbit breadth	38.65	.17	23	*38.12	.17	33	39.63	.21	34
Right orbit breadth	39.33	.23	21	*38.43	.17	35	39.74	.24	35
Interorbital breadth	22.03	.21	35	20.71	.17	41	21.61	.27	38
Biorbital breadth	*99.85	.43	26	*95.81	.36	32	98.62	.50	32
External palate length	53.67	.29	21	52.48	.35	27	54.68	.34	34
External palate breadth	63.77	.58	22	*60.77	.34	22	64.03	.37	29
Symphysis height mandible	32.99	.74	9	30.00	.49	23	32.93	.38	29
Condylo-symphysis length	102.50	2.77	4	99.90	1.20	10	104.12	.92	16
Bicondylar breadth	123.13	2.00	3	*115.41	1.32	11	124.64	1.17	14
Minimum breadth asc.ramus	31.87	.36	8	31.36	.33	25	31.36	.31	23
Mandibular ramus angle	124.50	1.83	7	122.94	1.03	18	122.95	.61	22
Cranial index	*73.23	.26	55	*74.55	.23	54	*74.08	.25	43
Length-height index	*69.81	.34	36	72.10	.35	42	71.69	.33	36
Length-auricular ht.index	*60.67	.28	48	62.38	.23	52	62.27	.25	44
Breadth-height index	95.99	.53	35	*96.33	.52	42	*96.28	.53	36
Breadth-auricular ht. "	83.60	.33	49	*83.93	.30	54	*83.97	.40	43
Fronto-parietal index	69.87	.35	43	68.78	.30	46	*69.85	.39	41
Cranio-facial index	*94.55	.65	20	92.37	.47	24	93.37	.29	33
Zygo-frontal index	73.39	.57	19	73.71	.44	24	*74.49	.42	33
Fronto-gonial index	105.90	2.92	5	102.37	1.77	8	106.70	1.16	20
Zygo-gonial index	77.50	1.45	5	76.07	1.59	7	79.34	.79	19
Facial index	83.90	2.36	5	89.25	2.04	8	90.33	.73	23
Upper facial index	51.03	.78	15	52.79	.50	21	*54.25	.40	32
Nasal index	51.55	.80	20	48.39	.52	31	48.13	.47	36
Left orbital index	83.54	.85	22	84.07	.79	30	83.56	.57	33
External palatal index	119.30	1.19	20	114.80	.93	20	117.43	.64	27
Reconstructed stature	163.43 cm.		7	161.26 cm.		4	163.85 cm.		14
Deviations from total series									
in 38 measurements	1.53 mm.			2.68 mm.			1.69 mm.		
in 23 indices	1.40			.94			1.14		
Mean % of total series variability constants	98.07		25.3	90.03		30.3	85.92		32.6
Mean Sigma Ratio (N > 14)	104.06	(32)	30.7	92.61	(35)	34.2	99.00	(38)	34.2

Note : values deviating from the total series by 2.50-2.99 x p.e. are starred, by

I I I
contrast with total series of mainland Greeks dating from before 3000 B.C.- 1300 A.D.

TYPE F Dinaric-Mediterranean			TYPE E Mixed Alpine			TYPE C Alpine			TYPES A & B Composite
Mean	p.e.	N	Mean	p.e.	N	Mean	p.e.	N	Mean
1446.78		*	1493.90		*	1434.36		*	1411.03
*510.87	2.20	16	*528.04	2.09	23	511.62	1.58	32	516.30
*368.65	2.16	16	377.71	1.35	21	*365.33	1.47	21	378.95
126.33	.77	12	130.50	1.08	21	126.92	.85	24	126.45
128.50	1.00	12	127.17	1.13	21	126.25	.83	24	128.99
118.68	1.42	11	118.62	.76	17	*114.59	.86	22	118.18
309.88	1.20	17	*317.29	1.33	21	*313.00	1.47	30	304.55
181.74	.78	19	186.00	.63	29	*177.65	.64	37	186.45
142.56	.55	18	*144.56	.55	27	*144.85	.56	39	137.41
135.37	.86	16	134.11	.84	18	132.52	.70	29	132.12
117.42	.58	19	*117.88	.58	26	116.92	.51	37	114.87
95.18	.61	17	*99.20	.72	26	97.00	.47	34	95.26
117.39	1.57	9	*125.62	1.09	16	*120.63	.72	22	115.88
112.24	.57	11	*114.83	.85	18	111.86	.71	22	111.65
114.33	.84	12	114.08	1.09	18	112.33	.74	23	115.89
98.67	1.06	12	99.07	.66	14	*94.80	.60	20	97.76
100.80	.74	15	102.43	.82	14	*97.65	.45	26	100.24
96.00	.52	15	95.00	1.00	9	93.21	.67	24	96.33
50.71	.44	17	51.71	.96	14	51.14	.41	29	50.37
87.00	.54	17	88.70	1.06	10	87.42	.42	26	86.22
92.27	.61	17	*95.50	.96	10	93.50	.39	26	93.28
*72.33	1.15	17	68.10	1.95	10	69.17	.51	24	67.30
56.50	1.40	14	57.17	1.96	9	*58.79	1.14	21	54.78
133.89	1.08	18	133.62	.86	16	133.00	.84	25	128.99
97.23	1.37	11	99.39	1.10	9	99.83	1.27	21	98.23
116.57	.45	14	109.70	1.34	10	109.83	1.15	21	110.75
*71.88	.51	19	67.08	.66	12	*65.81	.58	27	66.86
52.20	.48	19	49.43	.54	14	49.14	.41	28	49.07
24.47	.28	19	24.57	.45	14	24.64	.26	28	24.37
11.83	.29	18	12.73	.39	22	12.45	.23	31	12.25
18.92	.36	13	17.54	.64	11	16.62	.22	21	17.27
33.77	.50	15	32.46	.32	13	32.61	.30	26	32.20
33.12	.47	17	32.71	.30	14	32.56	.29	27	32.30
39.87	.34	15	*40.21	.41	14	39.71	.22	24	38.39
39.81	.32	16	40.57	.33	14	39.92	.21	24	38.88
21.67	.33	18	21.90	.30	20	21.88	.26	33	21.37
98.71	.87	17	99.47	.65	17	99.16	.48	25	97.83
52.58	.37	17	55.00	.57	10	51.74	.49	23	53.08
83.82	.56	17	*66.29	1.09	7	63.20	.70	20	62.27
33.44	.49	16	30.90	.83	10	30.48	.42	25	31.50
105.33	.71	7	104.79	1.40	7	101.25	1.27	16	101.20
121.93	2.34	7	125.64	1.31	7	122.23	1.34	15	119.27
31.60	.33	15	31.44	.61	11	*30.62	.31	21	31.62
123.73	1.35	13	126.70	1.80	10	121.30	.96	20	123.72
*78.61	.27	18	77.83	.19	27	*81.77	.34	37	73.89
74.31	.37	16	72.11	.51	18	74.84	.38	29	70.95
64.55	.34	13	63.69	.38	26	*65.88	.33	34	61.52
94.75	.45	16	92.39	.65	18	*91.40	.54	29	96.16
82.00	.38	18	*81.62	.54	25	*80.58	.34	36	83.77
66.50	.68	16	68.30	.49	25	*66.72	.36	32	69.32
93.68	.60	17	91.43	.59	15	*91.26	.55	25	93.36
71.00	.58	16	74.19	.79	16	72.07	.42	23	73.55
104.83	1.41	9	100.87	1.60	8	103.34	1.12	19	104.13
74.80	1.01	10	74.37	.66	8	75.34	.72	19	76.79
89.29	.79	14	83.87	.91	8	*82.50	.88	19	86.58
53.33	.41	18	50.82	.76	9	*49.54	.46	24	51.70
*46.92	.61	19	48.65	.93	13	50.29	.62	28	49.97
84.50	1.31	15	80.82	1.03	12	82.50	.70	24	83.80
118.62	1.01	16	118.64	1.33	7	*121.28	1.18	18	117.05
162.37 cm.		6	161.85 cm.		3	159.62 cm.		13	162.35 cm.
1.31 mm.			1.99 mm.			1.95 mm.			
1.26			1.36			1.86			
86.66 ?		15.3	(96.78)		13.0	92.88		25.6	
98.92 (31)		18.9	94.10	(16)	22.1	105.32	(39)	26.2	

3.00-3.99 x p.e. underlined, by 4.00 or more x p.e. both starred and underlined.

T A B L E

Type descriptions, based on metric and morphological deviations from total series ;

Deviations:	T Y P E A Basic White (Rugged Mediterranean)	T Y P E B Classic Mediterranean	T Y P E D Nordic-Iranian
Signi- metric	11.37 %	52.28 %	31.81 %
fic- indicial	31.25 %	18.75 %	31.25 %
ant morphological	29.79 %	39.36 %	35.11 %
Mean age	39.7 years (56)	38.3 years (58)	41.0 years (46)
Skull vault description	Rugged, easy to sex. Large, long, long-based Dolichocrane, low rel. to length; wide frontal rel. to breadth. Lack of crania.	Gracile, light, hard to sex. Small, with narrow base. Just dolichocrane, with rel. long parietals 35.01% of sagittal arc. Excess of calvaria	Muscular, heavy, easy to sex. Large, long, high, long-based, with deep occiput. Dolicho, with rel. long occipital 32.3% Excess of crania
Headform	Pentagonoid	Pentagonoid	Ellipsoid & ovoid
Browridges	Heavy. *8.3% continuous	Small to medium	Large. Strong glabella
Forehead & frontal	Low, sloping, & constricted forehead, with small bosses.	Low, erect, and narrow forehead : paedomorphic.	Receding, fairly high forehead, with *median ridge. Tilted frontal.
Parietal	Angular and crested	Angular : big bosses	Full : weak bosses
Temporal	Much flattened	Flattened	Slightly flattened
Mastoids	Large and massive	Medium-small	Large and rugged
Occipital	Well-curved, with lambdoid flattening	Sharply bent, with weak inion and torus	Full and deep curve, full lambda, big torus
Base	Low occipital condyles, and medium-deep pharyngeal fossa	High basion. Thin tympanic plate, small postglenoid. *Weak pharyng. f.	Deep glenoid fossa and large postglenoid process
Face description	Medium size. Deep jaws. Variably low-faced, broad-jowled. Short-nosed.	Small & compressed, with narrow nose & shallow mandible. Narrowed throughout.	Big & high, with large nose and long palate. High-faced & broad-jowled.
Outline	Trapezoid	Inverted triangular	Rectangular
Profile	Concave	Weak	*Convex
Orbits	Oblong	High, square, horizontal	Drooping
Cheekbones	Large and rugged	Small, weak, compressed	Large and *slablike
Nasion depr.	Deep	Slight	Medium
Nose	Coarse : straight profile; *blunt sills & small nasal spine	Small & narrow. Low root & wavy profile. Weak nasal spine	Long nose. High root & projecting bridge; concavo-convex. Big spine.
Palate	Large U outline. Torus rounded. *Slight alveolar prognathism	Narrowed, with slight alveolar prognatnism	Long and high-arched. Ridge torus. Large postnasal spine
Mandible and teeth	Deep, median, strong chin and everted angles. Edge bite. Lack of pyorrhea. Big lower third molars (5-5-4 cusps)	Small, narrow, weak jaw. Compressed angles. Shallow median chin. Overbite, and slight degree of teeth wear	Big, rugged jaw. Deep, *non-prominent, bilateral chin. *Everted angles. Upper third molars reduced (4-4-2 excess)
Mean "Deviation ratio"	Al 'Ubaid, Mesopotamia: 176.84 % Kish A & Y graves, Mesopotamia: 216.40 % Chalcolithic Megiddo, Palestine 86.87 %? Siculans, N.C.Sicily: 74.09 % Chalcolithic Sardinians: 100.30 % Neolithic type, Great Britain: 107.94 % Swedish Neolithic long-heads: 147.17 % (Type D, Greece: 92.83 %)	Badarians, Upper Egypt: 131.70 % Siwah Libyans: 67.86 % "Modern" Sicilians: 73.82 % "Modern" Spanish: 140.36 % From A & B composite Gizeh, Lower Egypt: 160.83 % Lachish, S.Palestine: 120.71 % Minoan Cretans: 116.74 %	Tepe Hissar, N. Iran: 148.57 % Bajuvars, Reihengräber, Bavaria: 52.28 % Anglo-Saxons, E.Anglia: 105.31 % Gallen monks, C.Ireland: 113.63 % (Type A, Greece: 99.71 %)

Note : characteristics deviating from those of the total series by 2.50-2.99 x p.e. where p is the percent occurrence of the morphological feature in the total series, n_2 the N of the total series minus n_1 (Yule and Kendall, '37, p.361). Mean Deviation of outside series from types as percentages of types' deviations from the total series the metric and indicial ratios so obtained. Genetic and growth correlations between

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with types' deviations from outside series as percentages of those from total series

T Y P E F Dinaric-Mediterranean	T Y P E E Mixed Alpine	T Y P E C Alpine
9.09 % 25.00 % 13.83 %	18.18 % 12.50 % 9.57 %	29.54 % 50.00 % 10.64 %
36.2 years (20)	39.9 years (26)	41.8 years (43)
Well-modelled. Medium size, and short. Narrow-based. High meso-crane; high rel. to l., narrow frontal, & short occiput. Excess of crania. Eyrsoid (-sphenoid)	Smooth-surfaced. Large, broad, long-based, with large frontal. Mesocrane, with rel. long frontal (34.68%). Otherwise intermediate. Varied	Variable ruggedness. Medium size. Short & broad, and short-based. Brachycrane; high rel. to l., low rel. to br. Short parietals and occiput. Excess of crania. Ovoid, sphenoid, spheroid
Medium *Sloping and flat-curved forehead, markedly constricted Full. Postcoronal dip Medium fullness *Medium-large, and long Slight bend, with flat cerebellar region. High condyles & basion. Shallow glenoid fossa, & elliptical audit. meatus.	Medium High, vertical, & wide forehead: no constriction, and large bosses *Full. Flat at obelion. Well-filled Medium and weak Medium-slight curve. *Weak inion Lowish condyles. Rounded auditory meatus, with thick tympanic plate	Medium Broad and full forehead, of variable height Well-filled Bulging. *X pterion. Medium Flat curve, and strong torus *Depressed basion. Slight thickening of tympanic plate
Large, with long nose & deep jaws. Relatively broad-cheeked cpd. to pinched forehead Long hexagonal Straight	Medium size, with wide orbits. Low-faced, with weak jowls. Otherwise intermediate Inverted trapezoid Retreating	Small size, low, short, with short palate. Low-faced, with rel. broad nose Rounded square Concave
Big, rhomboid, *sloping Large and *flaring Slight Long and *narrow-bridged. Classic profile. Small lacrimal foramen. High-arched. *Well-preserved alveolae, but crowded teeth.	Low, broad, rhomboid Weak lateral projection Medium Low-bridged nose, with *high root. *Sharp sills Lowish and *capacious palate, with lump torus.	Broad and intermediate Prominent laterally Medium Non-projecting, lowish, and *concave-profiled. Variable minorities. Short and low. Alveolae orthognathous, and somewhat absorbed.
Long jaw, with open and *everted angles, deep chin. Lack of teeth loss. *Slight shovel incisors & *Excess of 4-4-4 cusps.	Wide and delicate jaw, with open angles. *Good teeth, and an overbite	*Strong chin; *non-muscular & square angles. Edge bite, worn teeth; lacks shovel incisors. *Excess of teeth loss before death
Sakkarah, Lower Egypt, Dynasty IV: 102.23 % ? Sedment, Lower Egypt, IX: 141.72 % Thebes, Lower Egypt, XVIII-XXI: 111.55 % Bronze Age Cypriotes: 154.46 % Ophrynion, Roman Troad: 127.89 % "Modern" Greeks, Anatolia-Thrace: 106.26 % "Modern" Serbs and Croats: 122.26 % "Modern" Slovenes: 127.46 %	Scyths of Bessarabia: 121.08 % Illyrians of Carniola: 111.38 % Etrusco-Romans, Tarquinia: 89.71 % "Modern" Basques, Guipuz- 123.18 % Guanche of Canary isles: 113.59 % Merovingian Franks of N. France: 100.39 %	Bronze Age east Cypriotes: 111.77 % "Modern" Carinthians: 63.97 % "Modern" foothill Bavarians: 92.94 % Medieval Hythe, Kent, England: 63.59 %

are starred, by 3.00 x p.e. or more underlined. Probable Error is $.67449\sqrt{\frac{pq}{n_1+n_2}\cdot\frac{n_2}{n_1}}$ q is 100 minus p, n_1 is the N of the type subgroup, and Ratio is obtained by taking separately the mean metric and mean indicial deviations in the measurements and indices available for any given outside series, and averaging characters obviously exaggerate such ratios.

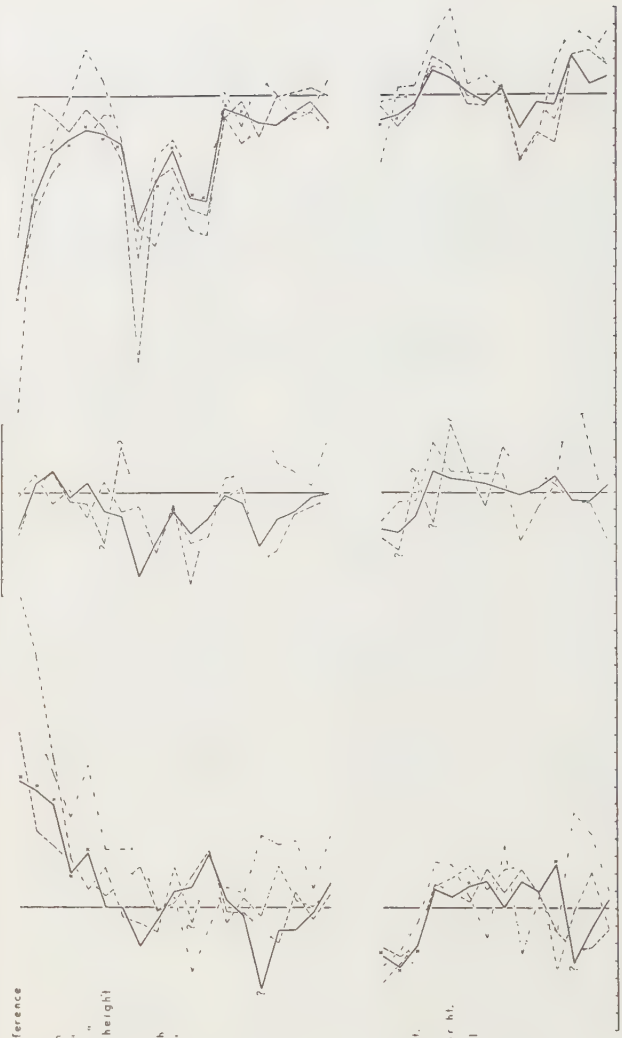

Fig. 11 Metric and indicial deviations of the "Mediterranean" types of ancient Greek male skulls (types A and B, and the composite formed by combining them) from the total series, with approximations to outside groups. Note wide divergence of the scanty A1 'Ubaid series from Basic Whites in an "Iranian" direction (compare fig. 12). The facial shortness typical of Greeks is also clear.

not be overlooked at any period when the Greek mainland shows an even domination of types A and B over the others.

The name Nordic-Iranian is compounded for type D because it contains slightly divided tendencies. The heavy Nordic-Iranian skull is large, long, and high, with long base and peculiarly deep occiput. A well-filled appearance and a smooth-contoured ellipsoid or ovoid norma verticalis set off the skull's sharply cut muscle attachments and well developed browridges. Considerable backward tilt of the frontal goes with a receding and capacious forehead. Like the frontal the parietals are smooth and weak-bossed with very little lambdoid flattening, though some occipital "overlap" may tend to occur. A powerful torus divides the full cerebellar region from the cerebral bulge of the occiput above, and the appreciable depth of the rear third of the vault is reflectd in the long occipital arc. The high, leptoprosopic, face is rectangular, combining broad forehead and jowls with relatively narrow midfacial region. Thus the noticeably drooping orbits are enclosed by large but compressed and slightly retreating cheekbones, and slight midfacial protrusion supports the aquiline nose. This nose is large in all dimensions, high at root and bridge, concavo-convex and markedly salient in profile, with a strongly jutting spine. The long and high-arched palate shows neither the modern "Gothic" narrowing nor any alveolar prognathism. The jaw is big and rugged, with some eversion of the widely spread angles and cleft and relatively deep chin whose lack of prominence suits a variable trend toward a convex facial profile. A reduction in size of the upper third molars seems unconnected with other masticatory features.

The Nordic-Iranian type is fairly homogeneous, though it masks some diverse trends,[14] and excess variability is centered in the minimum frontal and upper facial breadths as well as parietal length and nose height (compare Breitinger, '38).

[14] Nordic-Iranians include four of the original subgroups: D 1, the "Iron Age Nordic" (Coon, '39, pp. 292–293), with full and cylindrical vault, almost mesocrane, with big forehead and rectangular face well set back beneath it, drooping rhomboid orbits, retreating cheekbones; D 2, the "Corded Nordic" (Coon, '39, p. 85 and table 12, Debetz, '30), with high, narrow, ellipsoid vault and heavy browridges overhanging horizontal orbits — features which become less extreme in the Iron than in the Bronze Age as in Central Europe; D 4, the Aegean-Anatolian version of the "Iranian" type, with medium-large, bluntly gabled, rounded pentagonoid to byrsoid vault, narrow forehead, and characteristically deep, down-bulging occiput, with rectangular face, high rhomboid orbits, a notably big and sweepingly salient hawklike nose, and resulting convex profile linked with retreating chin and short ramus of deep and tilted jaw (all these features being less extreme in Greece than in Vallois' ('39) ill-filled, hyperdolichocrane, broad-nosed, prognathous Proto-Iranian type at Sialk); and D 3, an intermediate Iranian-Mediterranean form, short-faced, and approximating Coon's Danubian and Cappadocian types (Coon, '39, pp. 85, 137–139).

These regional variabilities suggest Central European Nordic versus Near Eastern contrast. It is not surprising that Nordic-Iranians show no significant differences from Bajuvars from Munich Reihengräber (Kramp, '38, and Wallis in Coon, '39, p. 664, table 44) as seen in table

T A B L E

Cranial series from sites outside Greece for comparison with morphological types, to

	FOR TYPE A N.W.Siculans Isnello N.C.Sicily Siculan I(?) ca.2000 B.C. (Giuffrida-Ruggeri)		FOR TYPE B S.Egyptians Badari Upper Egypt Badarian ca.4000 B.C. (Stoessiger, Derry,Morant)		E.Libyans Siwah N.E.Libya pre-Roman (Iron Age??) (Derry)		FOR TYPE D Proto-Nordics Tepe Hissar North Iran Bronze Age 3rd mill.B.C. (Krogman)		Bajuvars Near Munich S.Bavaria Reihengräber 580-730 A.D. (Kramp,Wallis in Coon)	
Character	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N
Horiz. circumf.	528.54	13	500.0	80	510.19	65	523.46	39	527.0	60
Sagittal arc	376.86	7	371.3	79	374.15	64	385.85	39	379.0	66
Frontal arc	125.93?	*	126.9	79	125.94	66	132.05	38	128.2	68
Parietal arc	129.36	11	129.6	79	130.52	66	134.59	39	129.4	61
Occipital arc	121.57	7	114.7	78	117.66	64	119.46	39	121.2	42
Transverse arc	311.73	11	302.0	34	293.93?	65	312.39	38		
Cranial length	188.73	15	182.5	81	184.09	66	191.67	39	189.0	63
Cranial breadth	140.08	13	131.6	81	135.44	66	135.95	39	140.9	62
Basion-bregma ht.	133.83	6	134.1	81	131.47	66	138.49	37	134.1	34
Auricular height			115.7	41	114.54	65	117.25	36		
Min. frontal br.	96.64	14	91.1	81	92.22	66	97.21	39	98.2	66
Max. frontal br.	115.58	12			111.92	64				
Frontal chord									113.0	67
Parietal chord									116.8	61
Occipital chord									98.9	42
Bas.-nasion l.			100.3	76	98.45	64	104.81	37	103.4	29
Bas.-prosthion l.			98.5	40	95.05	59				
Facial angle	87.80	5	84.0	33	85.67	59	86.78	36		
Bizygomatic br.	133.18	11	123.6	61	124.83	55	130.03	35	133.7	33
Bigonial breadth	103.00?	7?	91.6	40	92.79	7	100.72	32	102.9	25
Face height	(112.69)	*	(115.0)	*	111.50	7	119.50	32	118.3	25
Upper face height	66.36	11	68.5	43	68.30	60	71.21	39	72.8	48
Nose height	51.09	11	48.8	43	50.34	64	51.21	39	53.5	49
Nose breadth	24.30	10	24.8	76	23.26	63	25.51	39	25.2	47
Left orbit height	31.82	11	31.6	37	32.97	54	32.15	39		
Right orbit ht.			31.5	38	33.09	61			32.6	53
Left orbit br.	38.91	11	37.4	37	38.91	63	40.51	35		
Right orbit br.			38.3	38	39.27	62			38.8	40
Interorbital br.	22.09	11	21.7	40	20.39	64	22.46	35		
Symphysis height	32.30?	10?	32.5	72	31.57	7	37.03	32		
Condylo-symph.l.							110.50	30		
Bicondylar breadth			109.9	36	113.21	7	117.66	29		
Min.br.asc.ramus	32.33?	9?	33.9	79	31.14	7	33.75	32		
Mandibular angle	119.67?	6?	120.0	34	127.00	7	124.27	30		
Cranial index	73.68	13	72.1	81	75.37	*	70.85	39	74.7	61
Length-height	70.53	6	73.7	77	71.42	*	72.16	37	71.1	34
Length-aur. ht.			63.4	*	62.22	*	61.17	*		
Breadth-height	96.27	6	98.2	77	97.07	*	101.81	37	95.1	*
Breadth-aur. ht.			87.9	*	84.57	*	86.24	*		
Fronto-parietal	68.98	*	69.2	*	68.09	*	71.72	39	69.8	51
Cranio-facial	95.06	*	93.9	*	92.17	*	95.69	35	94.5	23
Zygo-frontal	72.55	*	73.7	*	73.88	*	74.76	*	73.4	23
Fronto-gonial	106.59?	*	100.5	*	100.62	*	103.61	*	104.8	*
Zygo-gonial	77.33?	*	74.1	*	74.33	*	77.46	*	77.0	*
Facial index					89.32	*	91.82	29	90.3	16
Upper facial	49.95	11	55.4	*	54.71	*	54.79	34	53.8	18
Nasal index	47.64	10	50.9	42	46.21	*	49.87	39	47.6	45
Orbital index	81.83	11	84.7	37	84.73	*	79.36	*	85.1	36
"Deviation ratio"	74.09 %		131.70 %		67.86 %		148.57 %		52.28 %	

Note : asterisks mark indices calculated from the means. Measurements known to di- divergence or other uncertainty are queried. Mandibular measurements of the Isnello Bajuvar series measured by Kramp is identical with that studied earlier by Wallis. warping and breakage; though this probably applies to other series of similar date 64.70 (10); palatal index, 117.28 (9).

12, though Bajuvars have a less rectangular face and more Alpinoid traits than are perceptible in Greek Nordic-Iranians. On the other hand the Tepe Hissar North Iranian Proto-Nordics (Krogman, '40) show exaggerated deviation from the Nordic-Iranian type because of

V

show directions of types' deviations from total series and racial position of Greeks

FOR TYPE F N.Egyptians Sedment Lower Egypt IX Dynasty 2100 B.C. (Woo)		Slovenes Carniola N.Yugoslavia "Modern" 19th A.D. (Weisbach, Morant)		FOR TYPE E Etr-Romans Tarquinia S.Tuscany Iron Age ca. 650 - (Schmidt, Morant)		Illyrians Magdalenaberg C.Carniola 100 B. C. Hallstatt (Angel)		FOR TYPE C Cypriotes Sites in N.E.Cyprus Bronze Age 2500-1200 (Fürst, Buxton)		Carinthians Greifenberg S.C.Austria "Modern" 17-19th A.D. (Shapiro)		FOR A & B Minoans Sites in E.Crete E.M.-L.M. 3000-1400 (Duckworth v.Luschan)	
Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N
511.7	40	510.1	60	523.6	85	528.59	15	510.87	38	517.92	272	515.9	21
373.8	36	359.8	60	375.6	81	383.80	10	368.23	37	364.03	261		
129.0	39	126.6	60			129.56	15	127.79	42	126.56	267		
129.9	40	123.8	60			130.00	16	127.18	44	122.51	223		
115.0	37	109.4	60			121.78	11	113.31	37	115.33	234		
314.9	39	314.6	60	319.3?	86	319.41	15	325.53?	32	315.52	273		
181.9	40	175.5	60	183.0	86	188.53	17	176.45	51	178.26	277	186.4	64
138.3	40	146.1	60	143.7	87	146.61	18	142.70	53	146.91	266	136.8	50
137.4	38	133.6	60	133.4	80	133.58	12	136.72	39	128.71	266	130.2?	20
115.3	39					118.39	18	117.45	33			118.9?	25
92.6	40	97.5	60	96.1	87	98.53	15	97.72	46	97.62	281	95.7	10
						123.96	15	118.66	42				
113.3	39					115.04	15	112.78	43				
115.6	40					117.26	16	110.50	44				
92.6	40	92.4	60	101.6	81	100.14	11	98.23	37				
100.8	37	99.9	60	101.0	80	103.67	9	99.67	36	98.05	263	100.0	23
96.0	37	94.6	60	95.4	78	101.00	7	94.52	25	93.22	180	95.9	11
84.4	37					87.10	10	84.50	20				
127.2	29	134.2	60	131.9	81	135.27	11	129.54	22	133.61	176	126.0?	5
92.0	32					101.50	12	97.50	8				
(119.2)	*					119.50	10	117.20?	5				
71.5	38	71.0	60	70.7	84	71.91	11	67.48	33	69.32	192	65.0	13
51.4	38	50.5	60	51.6	84	53.18	11	49.97	36	50.58	255	48.9	13
24.5	39	23.9	60	24.1	82	25.30	10	24.08	35	24.55	233	24.2	10
		33.0	60	32.9	84	34.17	6	32.42	36	33.38	247	31.7	22
33.3	40					33.29	7			33.50	252		
						40.33	6			39.61	246	39.5	13
		39.2?	60	38.6	84	38.86	7	39.28?	35	40.06	246		
39.7	35												
21.2	32					23.50	10	(25.5)	36				
										External palate length:			
33.7	33					32.92	13	32.00	8	52.01	183		
102.6	36					107.40	11						
114.3	26					123.30	10	120.00	6	palate breadth:			
33.3	35					30.15	12	32.50	8	63.39	116		
121.0	36					127.96	11	122.00	8				
76.1	40	83.4	60	78.6	83	77.94	16	80.97	51	82.51	261	73.39	*
75.5	38	76.1	60	72.9	80	71.27	13	78.14	39	72.40	260	69.85?	*
65.4	*					62.85	17	67.55	33			63.79?	*
99.3	*	91.4	*	92.83	*	92.58	13	95.57	39	87.82	251	95.18?	*
83.4	*					80.85	17	82.47	33			86.92?	*
67.0	*	66.7	*	66.87	*	66.86	14	68.56	46	66.42	264	69.96	*
92.0	*	91.8	*	91.73	*	91.95	11	90.78	*	90.82	176	92.10	*
72.8	*	72.6	*	72.86	*	73.28	9	75.44	*	73.06	*	75.95	*
99.3	*					102.95	11	99.77	*				
72.3	*					75.83	9	75.27	*	E.pal.index:			
						87.86	11	92.57?	3	121.48	116		
56.2	*	52.9	*	53.60	*	53.14	11	52.45	22	52.26	132	51.59	*
47.7	38	47.1	60	46.9	82	47.90	10	48.29	34	48.61	228	49.49	*
84.1	35	83.8	60	85.8	71	86.67	6	82.64	35	84.32	241	80.25	*
141.72%		127.46 %		89.71 %		111.38 %		111.77 %		63.97 %		114.25 %	

verge from the writer's technique are in parentheses; those suspected of technical series are doubtful since the jaws were sexed metrically. It is not certain that the All measurements on the Magdalenaberg series are dubious because of post-mortem and provenience. Magdalenaberg External palate length : 54.73 (11); palate breadth,

their consistently marked linearity and lack of any Alpinoid trends.[15] Resemblances to southeast English Anglo-Saxons (Layard and Young, in Brash, '35) and to medieval monks of central Ireland (Howells, '41) are adequate to confirm the Nordic direction of the type's deviation from the total series of Greeks and show up the palaeolithic survivor elements in these northwest Europeans. The Nordic-Iranian's overlap with the Basic White is obvious, just as Nordic and Atlanto-Mediterranean types overlap elsewhere, but ten significant metric and indicial differences are enough to show that they are not simply facial variants of a single type.[16] These comparisons greatly strengthen the case for an historic Iranian-Nordic racial continuity (Coon, '39, p. 128) from the Caspian to Scandinavia, and they suggest eastern and northern origins for the Nordic-Iranian type in Greece.

Type F is the least Alpine of two intermediate, plausibly hybrid forms, and is called Dinaric-Mediterranean. The medium-sized high mesocrane vault is short and relatively high, with relatively narrow base, and a marked constriction of the forehead which combines with full parietals to give a byrsoid (hanging waterdrop) norma verticalis. This pinching of the rather flat and sloping forehead is reflected in a tendency toward postcoronal depression. The occipital is short, nonprotuberant, and placed high, with a flat cerebellar region leading down toward vertically elongated mastoids and projecting occipital condyles. Norma occipitalis may be horseshoe shaped. The glenoid fossa is shallow. The face is big and high, with enough midfacial breadth contrasted with pinched forehead and jowls to give an elongated hexagonal (almost diamond-shaped) outline. This midfacial breadth is variable, depending on the tendency of the large cheekbones to flare and on the droop of capacious rhomboid orbits. Facial height is carried through in the long thin nose whose profile tends to continue the line of the forehead, and in the high palate (accompanied respectively by reduced bore of lacrimal foramen and by crowding of teeth) down to the long and deep jaw with its trend toward obtuse and slightly flaring angles. Well-preserved alveolae and rare teeth loss in life clearly connect with a younger than average age at death in this sample.

[15] Since ancient Egyptians, Mesopotamians, Iranians, and other inhabitants of the arid Near East differ consistently from all the Greek morphological types and from Europeans in general in their much greater linearity of vault and face, it seems likely that this linearity is largely an environmentally conditioned (climate, soil minerals, diet, water intake) feature which would tend to disappear in any group migrating to a less arid region.

[16] There is no reason to suppose that the Nordic-Iranian type in Greece was as blond as are Nordics in northern latitudes. In modern Greece the type shows brunet as well as blond individuals.

The Dinaric-Mediterranean is homogeneous as a whole but shows two slightly divergent trends [17] definitely enough to account for excess variability in the sagittal arc, bizygomatic, biorbital, orbital, and bicondylar breadths, fronto-parietal index, and profile angles of the midfacial region. In harmony with this the Dinaric-Mediterraneans show barely adequate approximations to two different sets of outside series, and deviate very little from the total series. The type resembles Lower Egyptian dinaricised Mediterranean series of the third and second millennia B.C. (Morant, '25, after Broca; Woo, '30; Morant, '25, after E. Schmidt), and in the other direction approaches dinaricised Alpine groups, including Roman inhabitants of the Troad in N.W. Anatolia (Virchow, 1879), modern Greeks almost wholly from Anatolia and European Turkey, modern Serbs and Croats of the Adriatic coast region and Dinaric Alps, and modern Slovenes of N.W. Yugoslavia (Morant, '28, all after Weisbach, 1881, 1884, '12), with poor resemblances to Bronze Age east Cypriotes (Fürst, '33, Buxton, '20). Since Lower Egyptians diverge from Dinaric-Mediterranean Greeks in the same linearity in which Egyptians in general differ from Greeks, and since the Cypriote, Anatolian, and Balkan groups are all too Alpinoid for close similarity, it seems best to think not only of plausible Egyptian and northern origins for the type but also of local hybrid formation.

Type E's close morphological approach to Alpine is the reason for calling it Mixed Alpine. It has a notably large and well-filled vault, long-based as well as broad, with intermediate proportions and a peculiarly broad and long frontal bone. The non-sloping, high, and fairly wide forehead has large bosses and is inflated rather than constricted postorbitally. The parietals are smoother and less striking, marked only by their contribution to lateral vault fullness and especially by the extensive obelion-lambda flattened plane leading down to the weakly curved occiput. The low face is so dominated by the large frontal that in spite of slight midfacial breadth tendencies clearest in the broad orbits the general facial outline is an inverted trapezoid. Non-flaring cheekbones border sloping orbits and suit non-projecting jowls. The low-bridged nose has a rather high, large root which emphasizes the lack of nasal saliency and fits the very orthognathous facial profile. Though both palate and jaw are large, their shallowness and the jaw's obtuse angles and incipient delicacy combine with an overbite to weaken the mouth region.

[17] These are: F 1 toward Mediterranean-Iranian features, with high nose root and browridge sweep, some midfacial and some occipital protrusion as among Iranians; F 2 toward the true brachycrane Dinaric, strongly orthognathous and with flatter occiput.

The Mixed Alpine type is homogeneous, but does show some inner divergencies suiting the excess variability in horizontal circumference, frontal bone diameters, orbital and nasal breadths, and facial angles.[18] The type shows close approximation to ancient Tarquinians of Etrusco-Roman makeup (Morant, '28, after E. Schmidt, 1887), and a good similarity with Merovingian Franks of northern France (Wallis in Coon, '39, p. 664, table 45), though both of these groups differ from Mixed Alpines in their greater facial and nasal heights and in Alpine and Nordic directions respectively. Adequate resemblances are found with Bessarabian Scyths (Donici, '28–'31, '30, '34–'35), with Carniola Illyrians (Angel, '42), with modern Basques of Guipuzcoa (Morant, '29, with data from d'Aranzadi), and with Medieval Guanche from Teneriffe (Hooton, '25). Illyrians are closest of these to the Greek Mixed Alpines, but differ strongly in their much higher and less orthognathous, more Nordic, faces. Though relatively low-faced, the Scyths are too small-skulled, Basques have too much facial constriction, and Guanche are too Mediterranean for close similarity. These resemblances as a whole suggest non-Near Eastern origins for Mixed Alpines, hinting that generalized Mediterranean-Alpine mixture took place throughout the Mediterranean-Black Sea strip of Europe and even Anatolia[19] with inevitable parallelism and that the type in Greece must be considered almost entirely a local hybrid form.

Alpine is the name given to type C because it includes brachymorph skulls. The medium-sized braincase is marked by wide parietals and considerable shortening which involves base, parietals, and occipital, with enough frontal region variety so that norma verticalis diverges from short ovoid to both spheroid and sphenoid. The forehead is broad and full, though narrow relative to the bulge of the sidewalls which may carry forward to the upper temples. The short occiput is much less curved than usual and shows a rugged torus which may compensate for reduced leverage and contrasts with lack of mastoid hypertrophy. The skull base tends to be flat. The Alpine face is low and orthognathous, subnasally shallow, and square in outline with rounded corners, tending toward hexagonal. The broad orbits droop little, and a slight flatness of face derives less from incipient prominence of

[18] The Mixed Alpine type includes three of the original 23 subgroups: E 1, showing larger, more angular vault, with smaller face; E 2, rugged Nordic-Alpine, with sloping forehead and wide face; E 3, a smaller and completely intermediate trend.

[19] Mixed Alpine similarities of the historic period Greeks from the Aeolian and Ionian coasts of Anatolia (Angel, '42, table IV column 7, after Schumacher, '26, Zaborowski, 1881, and Virchow, 1882, 1884) show that Greeks on both sides of the Aegean in classical times developed parallel mixtures.

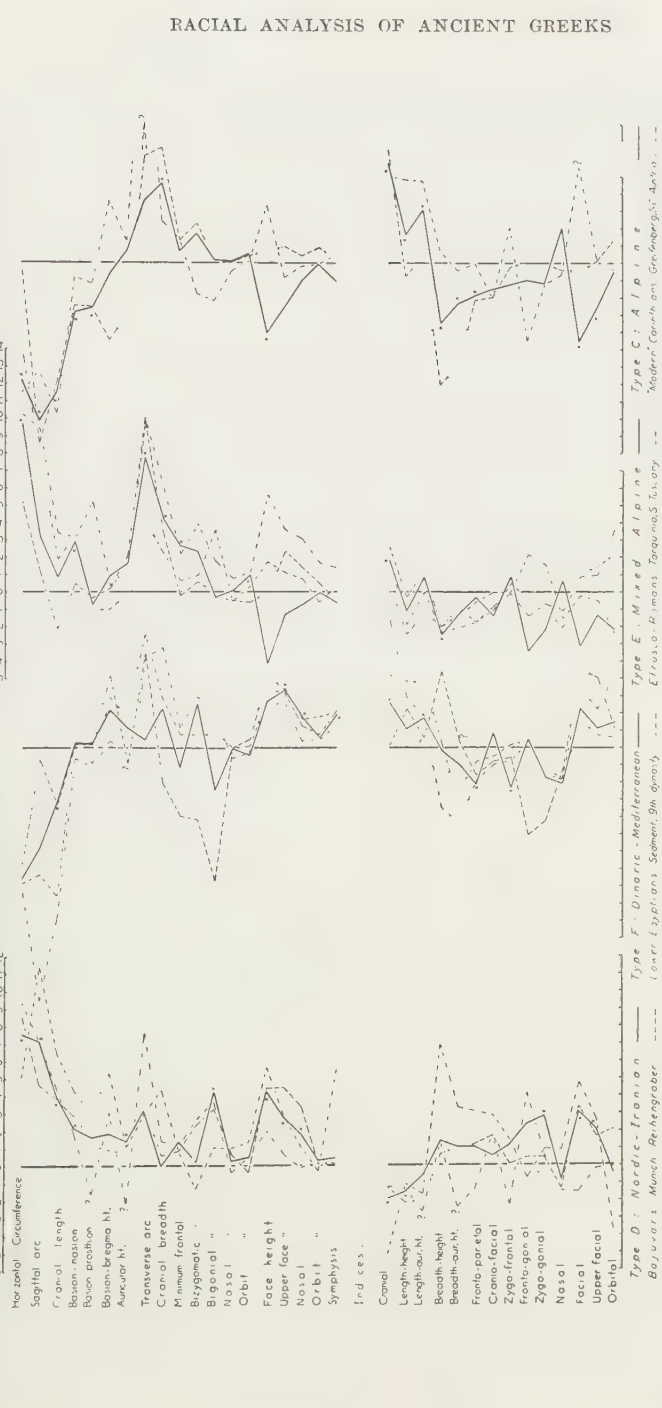

Fig. 12 Deviations of Nordic-Iranian, Alpine and the two intermediate Alpine-like types, Dinaric-Mediterranean and Mixed Alpine, from the total series and from various outside groups. Relatively wide approximation of the Dinaric-Mediterranean type to non-Greek series is a result of its hybrid nature: most intermediate groups contain balancing proportions of Mixed Alpine and Dinaric tendencies. Note general linearity of Near Eastern comparative groups here and in figure 11. Extreme facial shortening is typical of Greek Alpines and Mixed Alpines.

cheekbones than from insignificant nasal prominence. Thus dominant nose trends are toward shortening and non-saliency, generally with low root and bridge and concave profile. The mouth region is marked by alveolar retraction with correspondingly short and low palate, and projecting chin. Though slightly squared, the jaw is not rugged. And the Alpine type's statistically insignificant rise in age at death does not seem enough to account for a whole complex of poor teeth quality, marked wear and loss before death, alveolar absorption, and an edge-to-edge bite.

Like the Basic White type the Alpine type shows a noticeably raised variability, with excess variability in transverse arc, frontal chord, face height, palate and jaw lengths and breadths, nasal and interorbital breadths, and nasalia and jaw angles. These excesses suit the divergent tendencies within the Alpines.[20] Because the "European" tendencies are stronger than the "Eastern" or Asiatic Alpine ones (compare Coon, '39, p. 636) the Greek Alpines show close approximation to Carinthian villagers from Greifenberg in the Drave valley (Shapiro, '29) and to medieval inhabitants of Hythe in Kent (Stoessiger and Morant, '32), with adequate resemblance to Foothill Bavarians (Ried, '11), though they tend to have a lower face and a slightly less laterally expanded vault than these groups. On the other hand eastern Cypriotes of the Bronze Age (Fürst, '33, Buxton, '20) show only an adequate resemblance to the Alpine type, about as close as the Bavarians, and in terms of raw differences are as close to the Dinaric-Mediterranean as to the Alpine type. The Cypriote vault is higher and slightly narrower than the Alpine, with longer base, and the face and nose relatively narrower: divergences in a Dinaric direction, though the Cypriote total face height is clearly overestimated by 3–4 mm. as result of inadequate sample. All together the Greek Alpine type must have Near Eastern origins subsidiary to northern ones, perhaps of eventual mesolithic derivation in Central Europe. The type's similarities suggest continuity between both low-headed (compare Krogman, '33 and '37, Hittite period Alpines with Shapiro, '29) and high-headed (compare Cypriotes and Bavarians) Eastern Alpines and European Alpines.

[20] In the Alpine type are included five subgroups: C 1, C 2, C 3, respectively the typical globular, round-faced Central European Alpine, its paedomorphic and low-headed extreme, and a heavy, rugged, slab-faced and square-jawed brachycrane trend in a Borreby — Beaker direction; C 4, the typical Eastern Alpine, combines a short, high, planoccipital, sphenoid vault with face marked by sloping orbits, high nose, square gonial angles spread by anterior crowding of neck viscera and muscles; and C 5, the low-headed Eastern Alpine, with sphenoid-byrsoid vault with short occiput, broad base, squat height, pinched forehead, and squat face, never linear, sometimes with puffily convex nose. Neither C 4 nor C 5 is "Armenoid", though later both may contribute to it.

As seen in the last column of table 7 the mean total series measurements predicted by averaging the weighted means of the six types show no meaningful differences from the observed values in table 2, and I conclude that it is just as accurate and more vivid to describe the ancient Greeks dynamically in terms of the percentage occurence of types as in terms of mean measurements.

This and the foregoing comparisons validate the types. The Dinaric-Mediterranean, Nordic-Iranian, and Basic White are closest to the hypothetical average ancient Greek in measurements and indices combined, and the Classic Mediterranean is particularly close in proportions though not in measurements, as shown in the mean deviations of table 3. But in lack of significantly deviant morphological observations, seen in table 4, it is the Alpine, Mixed Alpine, and Dinaric-Mediterranean types which are closest to the average. Hence the ancient Greeks might be considered an intermediate "blend" of slightly diverse linear and lateral types with the former dominating the measurements and the latter the morphology. But the numerical dominance of rugged and gracile Mediterraneans, seen in the last column of table 6, and the relative rarity of the two intermediate types show that the term "blend" is a misnomer. This term's inaccuracy is confirmed by the excessive variability of the total series and period groups compared to the six types. By now it is clear that this high variability is a result of incomplete blending and of juxtaposition of more individuals of contrasting (not intermediate) type than in most populations. Hence both the process of formation and the notable heterogeneity of the ancient Greeks are illuminated through use of types in a way impossible from means and sigmas alone.

TABLE VI

Percentages of occurrence of six male morphological types in eight period groups

Morphological type	NEOL.-E.H.	M.H.-L.H.II	L.H.III	CEPHALENIA	EARLY IRON	CLASSIC	ROMAN	BYZANTINE	TOTAL SERIES
C : Alpine	17.25	13.04	10.00	6.90	30.77	*12.07	19.05	27.59	16.08
E : Mixed Alpine	3.45	*21.74	7.50	13.80	11.54	13.80	14.29	3.45	10.98
F : Dinaric-Mediterranean	6.90	13.04	5.00	0	*19.23	*3.45	*19.05	6.90	7.84
D : Nordic-Iranian	17.24	30.43	7.50	10.35	11.54	*27.58	23.80	17.24	18.43
B : Classic Mediterranean	24.13	8.70	27.50	31.03	15.38	20.70	14.28	*37.92	23.14
A : Basic White	31.03	13.05	42.50	37.92	11.54	22.40	9.53	6.90	23.53
Number skulls	29	23	40	29	26	58	21	29	255
Deviation from previous period	3.22	12.54	16.08	4.23	14.36	11.49	7.69	10.75	

This suggests that other samples, even those which are considered "homogeneous," might yield more information if they were treated

in the same way. The types established in this study apply throughout the white race's range except for regions dominated by Paleolithic survivors (Coon, '39, pp. 291, 294–295, map 9) other than the Alpine type. Cranial features of rugged and gracile Mediterranean, Nordic, and Alpine types have been precisely described and validated. And such details as the facial rectangularity of Nordics and of Iranians, the edge-to-edge bite of Alpines, and the mandibular compression of Medi-

TABLE VII

Measurements and indices of period groups and of total series predicted from type percentages; and deviations of observed values (Table VIII) from predictions

	NEOL.-E.H.	M.H.-L.H.II	L.H.III	CEPHAL-LENIA	EARLY IRON	CLASSIC	ROMAN	BYZANT-INE	TOTAL SERIES
Horiz.	517.83	520.87	518.58	519.25	515.92	519.98	517.89	513.78	518.22
circ.	-2.40	-.52	-.58	5.74	2.23	.14	.58	-3.69	.16
Sag.	374.53	375.77	373.52	375.79	371.62	375.89	373.59	371.15	374.46
arc	-.75	1.25	3.50	1.55	2.56	-.51	-4.77	-.87	.00
Trans.	308.38	311.67	307.61	308.20	310.47	309.77	310.78	308.26	309.21
arc	1.78	*5.77	1.27	-.29	-1.71	-.27	-2.70	.84	.21
Length	185.26	185.57	186.06	186.25	182.84	185.89	184.16	182.53	185.02
	-.12	.38	.68	2.23	1.12	.76	-1.21	-1.76	.14
Br.	139.94	141.84	139.49	139.36	141.77	140.31	141.42	139.91	140.34
	-.36	.74	.66	-.43	-.01	.37	.58	-2.02	-.03
Auric.	116.07	117.03	115.84	115.81	116.61	116.41	116.77	115.77	116.25
ht.	1.35	1.54	.10	-.41	-.73	-.23	-.39	.02	-.01
Min.fr.	96.25	97.13	96.20	96.29	96.42	96.70	96.60	95.66	96.41
br.	-.15	-.71	-.42	-.33	-1.16	-.09	.72	.47	-.05
Bas.-	100.52	101.52	100.77	100.91	100.12	101.10	100.78	99.41	100.68
nas.l.	1.10	*-3.52	*-2.04	1.29	.30	.01	.72	.84	-.16
Bas.-	96.76	96.01	*96.36	96.21	95.17	96.09	95.61	94.79	95.86
prosth.	1.95	*-3.39	*-3.11	3.01	-.36	.12	.89	.65	-.11
Bizyg.	130.86	132.04	132.04	130.41	131.86	131.05	131.65	129.94	131.01
br.	-2.66	.60	*-2.79	-.79	.67	.43	2.18	2.17	-.35
Bigon.	99.75	100.48	99.51	99.37	97.59	100.17	99.63	98.17	99.58
	*-6.37	-3.80	1.65	-1.37	*2.67	*2.71	.21	*4.33	.12
U.face	67.76	68.69	67.36	67.27	68.57	68.10	68.60	67.58	67.87
ht.	*2.80	-.12	1.05	-2.00	-.57	.46	.75	1.20	.51
Nose	49.78	50.45	49.96	49.41	50.12	50.02	50.39	49.85	49.88
ht.	1.00	-1.12	-.49	-1.79	.13	.82	1.55	.47	.30
Nose	24.53	24.61	24.52	24.49	24.52	24.55	24.54	24.35	24.52
br.	-.53	-.49	-.52	.01	-.17	.22	.58	.35	.02
Symph.	31.78	31.99	31.78	31.59	31.70	31.78	*31.86	31.11	31.67
ht.	1.55	-.92	.82	-1.84	.91	.39	*-3.00	-1.24	-.12
Cranial	75.70	76.42	75.12	74.95	77.72	75.59	76.93	76.76	75.99
index	.06	.69	.89	*-1.29	-.43	-.11	.67	-.14	.00
L.-aur.	63.37	63.15	62.20	62.11	63.82	62.64	63.46	63.40	62.83
ht.	.08	.75	.48	-.70	*-1.03	-.40	.28	.82	.02
Br-aur.	83.04	82.71	83.19	83.26	82.23	83.08	82.57	82.78	82.92
ht.	.83	.62	-.37	.41	-.36	-.49	-.55	1.35	.01
Fr-par.	68.74	68.52	68.95	69.08	67.88	68.87	68.20	68.26	68.84
	-.13	-1.31	-.83	*1.37	.33	.27	.46	1.20	-.23
U.fac.	51.90	52.22	51.71	51.78	51.63	52.15	52.17	51.66	51.95
	*2.82	.06	1.12	*1.78	-.48	.42	-.43	1.27	.24
Nasal	49.60	49.05	49.92	49.87	49.17	49.38	48.89	49.03	49.41
	-1.54	-.62	-1.42	1.80	-.67	-.42	-.27	-.09	-.41
L.orb-	83.07	82.41	83.35	83.16	83.06	82.91	82.98	83.26	83.33
ital	-.22	-.28	1.82	-2.48	.50	.20	-1.36	.24	-.30
Stat-	162.16	162.39	162.42	162.32	161.79	162.38	162.15	161.51	162.14
ure	-4.41	-1.88	-3.58	1.00	-.71	3.00	2.71	4.26	.05
Deviations:									
metric	1.66	1.66	1.31	1.54	1.02	.50	1.39	1.39	.15
indicial	.81	.62	.99	1.40	.54	.33	.57	.72	.17

Note : for statistical purposes the p.e.s of the predictions are considered identical with those of observed values. Deviations of observed from predicted means are marked with one star if they exceed twice their probable errors, and with two stars if over 2.50 x p.e. No deviation reaches 3.00 x p.e. Predictions for a particular measurement of any given period group are calculated by averaging the types' means weighted according to the percentage frequency of each type in that period group. The discrepancies shown above result partly from inadequate samples, but to a greater extent from genetic effects which the types are too static to predict, as well as from environmental influences.

terraneans have been established objectively, even though the actual measurements of each type express a few local Greek peculiarities, such as facial lowness. It is also clear that mixture between Alpine and linear strains may produce individuals with long mesocrane skulls and low faces as well as a short-skulled, long-faced Dinaric intermediacy.

USE OF TYPES IN ANALYSIS OF GREEK RACIAL HISTORY

There are two tests of the usefulness of the types set up in the preceding discussion. The first of these is the accuracy of the predictions of the period group means, as shown in table 7. In no instance do these predictions differ significantly from the observed values in table 8 and they give a good general picture of the observed changes in racial pattern from period to period. Discrepancies occur, often as a result of inadequate numbers of fully measurable skulls, often as a result of environmental forces, and sometimes also of genetic factors beyond the scope of the chronologically inflexible types. But these are minor deviations. And since the changes shown in tables 8 and 9 result from genetic and from environmental forces combined and can be expressed accurately in terms of type percentages, the types must have some degree of genetic as well as phaenotypic reality. The second test of usefulness is the vividness which the racial types give to Greek racial history, and this can be judged only from study of figure 13, table 6, and the following paragraphs.

Racial analysis of Greece in these terms can be summarized as follows: (1) type distribution for the combined Neolithic and Early Bronze Age does not differ appreciably from that for the total series of males; (2) noticeable increases in Mixed Alpine and Nordic-Iranian types occur in the Middle Bronze Age, the latter element being emphasized by (3) the statistically significant reduction in Nordic-Iranian and rise to dominance of both rugged and gracile Mediterraneans in the Mycenaean period; (4) marked decrease in Basic Whites with corresponding significant increase definite for Alpines and probable for Dinaric-Mediterraneans in the Early Iron Age; (5) significant decrease in Classical times of Alpines and the two hybrid Alpine types taken as a whole, with corresponding increase in dolichocranes perhaps involving Nordic-Iranians more than the other two; (6) possible though unproven increase in Dinaric-Mediterraneans and decrease in Basic Whites in the Roman period, followed by (7) virtually significant Byzantine increase in Classic Mediterraneans since the Roman period, and in Alpines since the Classic period. A period by period consideration of the relation of

this racial picture shown in figure 13 to the measurements and observa tions tabulated in tables 8 and 9 will sharpen the historical meanin of the period samples and will clarify further the types and their use fulness.

In the much broken sample from the third millennium B.C. ther appears the combination of a medium-sized, scarcely mesocrane, some what high-vaulted and narrow-based braincase with a linear face com bining deep and compressed jaws with a protruding mouth region an fairly large nose. Though this picture of the average pre-Gree ("Pelasgian"?) inhabitant of Greece is somewhat exaggerated be cause of the scarcity of skulls with measureable faces, it is explicabl as a partial "dinaricisation" of robust and gracile Mediterranea strains by combination with Alpine, Iranian, and possibly also Dinari Mediterranean types. The measurements appear to overstress a Dinar rather than short-faced Mixed Alpine intermediacy more typical fo Greece at later periods. But it is clear that the basic racial mechanis of this area was already operating before 2000 B.C., and that Alpin Nordic-Iranian, and Dinaroid strains mainly from ultimate Mesolith and ("Danubian") Neolithic origins in regions north and northea of Greece (compare Angel, '42 b, table IV, column 1, after Jaronof Drončilov, Popov, Pittard, Doniči) were less important in forming th original populations of Greece than were Basic Whites and delica Mediterraneans of southeastern insular and coastal Mediterranea origin.[21]

In the Middle Bronze Age the extremes of type are still furthe apart than in the variable third millennium B.C. sample. The averag show a larger, more mesocrane, shorter-based, well-filled vault with b forehead and low-bulging occiput. The more hexagonal face is lowe with straight profile, low orbits, shallow jaw, and a mainly aquilin nose with pinched root and interorbital narrowing. This contradicto description goes with an exceedingly high variability and results fro the juxtaposition rather than blending of Alpinoid and Nordic-Irania types with practical vanishing of Mediterraneans. Alpine influen overdominates the means, but stresses probable northern invasions into isthmian Greece. Other movements from far to the northeast

[21] As suggested elsewhere (Angel, '42 b) on the basis of unpublished skulls from Ea Bronze Age Corinth, Dinaric-Mediterraneans as well as Mediterraneans in Greece at this ti are plausibly derived from Lower Egypt or the Delta either directly or via Crete as much from the eastern Balkans.

[22] These probably took place toward the end of the period (L.H. I–II) and brought in Mix Alpines (Nordic-Alpines), according to unpublished skulls from Mycenae, Thorikos, a Eutresis.

east (Debetz, '30, and Krogman, '40) occurred earlier in the period, were more important, included Eastern Alpine as well as Nordic-Iranian elements, probably had repercussions in Anatolia (Krogman, '37), and must have been connected with the arrival of peoples speaking some form of Greek.

The Mycenaean sample has a less mesocrane, low, angular, and less well-filled braincase with less arched forehead. The face is slightly longer, with higher orbits and deeper chin, and is distinguished particularly by widely spread and square jowls. A weak and non-salient nose combines with striking alveolar prognathism and jutting chin to produce a concave total profile. Dominance by Basic Whites backed up by gracile Mediterraneans adequately explains these averages [23] and partly explains the striking decrease in variability from the colossal Middle Bronze Age value. Alpine and Nordic-Iranian strains were very thoroughly absorbed in formation of this homogeneous Mycenaean blend, and influence of the former on vault breadth and base shortness and of the latter on face heights and jowl breadth is perhaps stronger than their percentage figures show: many Basic White skulls now show Alpine or Nordic minor characteristics. The Mycenaean blend seems to be fundamental in all later Greek populations down to the present day. Its formation was principally absorption of Middle Bronze Age intrusive strains by the pre-Greek racial substratum. But the close similarity of the "Mediterranean" composite of types A and B to non-brachycrane Minoan Cretans is suggestive here, as shown in figure 11, and maritime reinforcement of these types and of Eastern Alpines is plausible.

The Submycenaean series from Cephallenia is culturally as well as racially separated from inhabitants of the isthmian region, serving as an example of the isolating effects of east Mediterranean geography in a phase of piracy and cultural change. The large, linear, scaphoid, coffin-shaped vault, and squat, low-orbitted, coarse-nosed, and slightly prognathous face differs from the Mycenaean series in much greater stress on the Megalithic (type A 1) segment of the Basic White type, plus a peculiar local exaggeration of the disharmonic Aegean face. But as pointed out in an earlier publication (Angel, '43) the Cephallenians exaggerate the Mycenaean divergences from the later isthmian Greeks and are a special survival from the pre-Greek racial substratum, perhaps with some Mycenaean Mediterraneans and also a trace of Alpine

[23] Relative lack of well-preserved complete crania, as in the third millennium B.C. group, affects the facial diameters, perhaps slightly exaggerating the facial heights.

T A B L E

Mean measurements, indices, and variability ratings of eight period groups of ancient

Character	NEOLITHIC AND EARLY HELLADIC a.3000-2000 B.C. Mean	p.e.	N	MIDDLE HELLADIC-LATE HELLADIC II ca.2000-1400 Mean	p.e.	N	MYCENAEAN LATE HELLADIC III a.1400-ca.1150 Mean	p.e.	N	CEPHALLENIA SUBMYCENAEAN a.1200-ca.1050 Mean	p.e.	N
Capacity	1442.60		*	1485.07		*	1435.82		*	1439.10		*
Horiz.circumf.	515.43	2.40	21	520.35	2.96	14	518.00	1.35	32	*524.99	2.46	21
Sagittal arc	373.78	2.63	11	377.88	3.09	13	377.02	1.46	31	377.34	2.26	19
Frontal arc	129.08	1.05	14	129.84	1.41	12	128.88	.62	16	126.66	.95	24
Parietal arc	128.38	1.33	16	127.30	2.45	10	129.30	1.13	15	129.46	1.37	23
Occipital arc	117.22	1.61	11	115.74	2.16	8	119.40	1.14	11	119.90	1.10	20
Transverse arc	310.16	2.92	12	317.44	2.03	15	308.88	.92	31	307.91	1.55	17
Length	185.14	1.04	22	185.95	1.17	20	185.38	.63	37	*188.48	.95	25
Breadth	139.58	.88	24	*142.58	.84	19	140.15	.57	39	138.93	.73	27
Basion-brgm.ht.	135.70	1.21	10	132.50	1.40	10	132.88	.74	26	133.44	.76	18
Auricular ht.	117.42	.81	19	118.57	.77	21	*115.94	.51	34	115.40	.47	25
Min.frontal br.	96.10	.63	20	96.42	.83	19	95.78	.41	37	96.62	.82	21
Max.frontal br.	115.83	1.35	12	116.50	1.92	8	116.04	.68	13	118.68	.91	23
Frontal chord	112.74	1.00	13	114.16	1.04	12	113.26	.46	16	111.84	.67	24
Parietal chord	113.98	.83	15	114.30	2.04	10	116.24	.84	15	115.98	.99	23
Occipital chord	98.68	1.09	11	96.84	1.01	6	99.10	1.81	10	100.60	1.05	20
Basion-nasn.l.	101.76	1.26	9	98.00	1.22	8	98.73	.72	26	102.20	.61	15
B-prosthion l.	98.71	1.17	7	92.62	1.13	8	93.25	.74	16	*99.22	1.14	9
Frontal angle	49.91	.80	11	51.64	1.23	11	49.97	.50	29	50.40	.36	15
Facial angle	85.37	.81	8	87.67	.71	12	86.40	.47	15	84.17	.85	12
Midfacial angle	*90.92	1.02	7	93.34	.79	12	94.26	.46	17	*90.50	.69	13
Alveolar angle	69.36	1.06	7	71.66	1.06	12	*65.24	1.06	16	64.50	1.41	12
Nasalia angle	56.00	2.09	4	54.22	2.06	7	57.62	.93	16	51.78	1.63	11
Bizygomatic br.	128.20	1.77	10	132.64	1.24	11	129.25	.87	20	129.62	.67	13
Bigonial br.	93.38	2.22	9	96.68	1.58	11	101.16	1.60	6	98.00		2
Face height	117.08	1.26	7	112.66	2.02	13	114.83	2.13	6	107.84		3
Upper face ht.	70.56	.82	9	68.57	1.19	14	68.41	.62	17	65.27	1.30	11
Nose height	50.78	.84	9	49.33	.79	15	49.47	.44	19	47.62	.72	13
Nose breadth	24.00	.37	10	24.12	.37	16	24.00	.28	19	24.50	.27	14
Upper nasalia b.	*12.46	.23	13	*11.61	.31	18	12.12	.21	34	12.43	.28	21
Lower nasalia	16.20	.46	5	16.10	.58	10	16.93	.49	14	16.62	.43	8
Left orbit ht.	32.56	.38	9	32.00	.43	11	33.11	.29	19	30.73	.65	11
Right orbit ht.	33.33	.46	9	*31.83	.26	12	*33.11	.35	19	31.21	.34	14
Left orbit br.	38.75	.40	8	38.85	.33	13	38.67	.23	21	38.18	.33	11
Right orbit br.	39.22	.39	9	39.58	.36	12	38.94	.30	18	*37.93	.25	14
Interorbital br.	21.86	.28	14	20.61	.31	16	*21.59	.21	34	22.43	.28	21
Biorbital br.	98.50	1.15	6	97.75	.78	16	97.67	.53	27	97.22	.72	18
Ext. palate l.	54.00	.48	9	53.40	.53	15	53.11	.41	18	53.67	.62	12
Ext. palate br.	64.00	.98	10	63.13	.77	16	63.07	.73	15	62.09	.25	11
Symphysis ht.	*33.33	.58	12	*31.05	.54	19	32.60	.80	10	29.75	1.60	4
Cond.-symph. l.	103.30	1.63	5	101.62	1.51	9	99.00	2.05	4	103.50		2
Bicondylar br.	114.84	2.63	6	120.22	2.34	7	121.00	1.42	4	115.50		2
Min. ramus br.	31.11	.60	9	32.53	.25	19	31.75	.31	8	31.00		3
Jaw angle	124.90	1.51	10	124.32	1.88	11	*118.50	.60	8	122.50		2
Cranial index	75.76	.56	23	77.11	.66	18	76.01	.38	37	*73.66	.44	25
Length-height	73.40	.58	10	72.50	.84	10	71.96	.44	26	70.78	.51	16
Length-aur. ht.	63.45	.44	19	63.90	.53	20	62.68	.35	33	*61.41	.33	22
Breadth-height	*97.80	1.21	10	*93.50	1.20	10	94.65	.65	26	95.94	.66	18
Breadth-aur.ht.	83.87	.59	19	83.33	.77	18	82.82	.53	34	83.67	.38	24
Fronto-parietal	68.61	.48	19	67.21	.80	17	68.12	.36	34	*70.45	.45	19
Cranio-facial	91.70	1.47	10	92.25	.82	12	91.50	.64	20	*93.50	.50	13
Zygo-frontal	75.40	.84	10	71.52	.82	11	73.22	.58	16	75.12	.56	13
Fronto-gonial	100.70	3.33	5	101.17	1.72	9	109.50	1.67	6	99.00		2
Zygo-gonial	77.25	2.44	4	72.75	1.24	8	77.50	.62	6	76.50		2
Facial index	92.83	1.58	6	*87.06	1.63	9	89.83	2.22	6	84.50		3
Upper facial	*54.72	.89	9	52.28	.89	9	52.85	.72	15	50.00	1.07	10
Nasal index	48.06	.81	9	48.43	.92	15	48.50	.83	19	51.67	1.17	12
Left orbital	83.07	1.44	7	82.41	1.25	11	85.17	.92	18	80.68	1.70	11
Ext. palatal	117.88	2.19	8	118.83	1.12	15	120.00	1.41	14	113.90	1.48	10
Stature	157.75 cm.		4	160.51 cm.		9	158.84 cm.		6	163.32 cm.		10
Mean deviations in 38 measures	1.30 (from to-			2.02			1.43			1.90 (2.25)		
in 23 indices	1.94 tal series)			2.38			1.81			2.79 (2.23)		
Variabilities:												
V L,Br,Au.h,Mn.fr	4.31		21.2	4.49		19.7	3.65		36.7	4.18		24.5
Mean Sigma Ratio	12.86	1.31	20.5	119.44	4.09	17.3	99.29	1.97	23.8	104.58	2.45	20.9
No.characters		8			15			30			16	

Note : values deviating notably from the preceding period's are marked as are values

V I I I

Greek males and of living Greeks (1939) from area south of Thessaly

EARLY IRON AGE SUBMYC.-GEOM. ca.1150-650			CLASSIC TO HELLENISTIC 650-150 B.C.			ROMAN AND LATE ROMAN 150 B.C.-450 A.D.			BYZANTINE AND MEDIEVAL a.450-1300 A.D.			37 LIVING GREEK MALES Cranial	
Mean	p.e.	N	Mean	p.e.	N	Mean	p.e.	N	Mean	p.e.	N	appr.	Mean
1440.03		*	1449.95		*	1439.71		*	1389.32		*	1458.3	
518.15	2.31	18	520.12	1.33	48	518.47	2.59	19	510.09	2.26	22	(520)	562.41
374.18	1.65	19	375.38	1.06	45	*369.82	2.23	19	370.28	2.07	18		
128.98	.71	21	*126.54	.65	50	126.08	1.03	14	122.90	1.02	5		
126.68	1.00	23	*129.64	.60	51	126.74	1.09	16	128.50		4		
117.68	.77	22	119.56	.69	40	117.70	1.00	15	121.84		3		
308.76	1.34	23	309.50	1.05	44	308.08	1.63	19	309.10	1.85	20		
183.96	.72	25	*186.65	.57	57	*182.95	1.19	21	180.77	.92	26	179.8	186.68
141.76	.86	25	140.68	.41	56	142.00	.76	21	137.89	.85	27	145.1	154.19
133.73	.79	22	133.04	.54	49	132.16	1.02	19	134.21	.72	19		
115.88	.61	25	116.18	.38	55	116.38	.70	21	115.79	.70	21	117.8	127.35
95.26	.70	19	96.61	.47	51	97.32	.66	19	96.13	.71	24	98.3	105.95
*119.50	.97	18	118.55	.62	43	119.95	.74	11	118.00	1.50	4		
113.76	.65	19	112.36	.58	41	112.68	.77	11	109.30	.94	5		
114.42	.79	23	116.08	.56	42	*112.80	1.03	13	116.00		4		
97.64	.62	21	98.08	.60	34	96.90	.98	12	101.84?		3		
100.42	.72	19	101.11	.48	44	101.50	1.01	16	100.25	.52	20		
94.81	.67	16	96.21	.66	33	96.50	.88	16	95.44	.73	18		
50.45	.51	20	50.00	.37	38	50.87	.45	15	50.20	.34	20		
87.06	.64	17	85.93	.47	29	88.47	.50	15	86.88	.59	17		
93.32	.50	17	93.74	.40	29	93.96	.52	15	93.32	.64	17		
68.24	.82	16	69.54	.97	29	73.44	.90	15	71.20	.95	17		
55.50	1.64	14	55.66	.95	24	53.84	1.43	15	*58.12	.79	16		
132.53	1.07	19	131.48	.63	29	133.83	1.03	18	132.11	.84	18	134.1	141.65
100.26	.88	17	102.88	.84	16	98.84	3.05	6	102.50	1.43	12	102.2	109.84
113.34	.99	19	115.98	1.03	19	*109.50	2.00	8	114.34	1.30	12	116.1	122.46
68.00	.66	19	68.56	.52	36	69.35	.82	17	68.78	.69	18	71.6	72.63
50.25	.44	20	50.84	.36	37	51.94	.59	17	50.32	.41	19	52.3?	55.32
24.35	.27	20	24.77	.21	35	25.12	.33	17	24.70	.24	20	25-??	36.57
13.16	.47	19	12.28	.26	43	11.37	.56	16	12.13	.29	24		
18.17	.31	12	17.28	.25	18	16.92	.41	13	16.78	.20	18		
32.16	.34	19	32.89	.21	37	32.41	.39	17	33.12	.48	17		
32.70	.37	20	32.81	.20	36	32.64	.49	14	33.21	.43	19		
39.12	.31	17	39.71	.21	35	39.69	.32	16	39.67	.22	18		
39.47	.29	19	39.92	.21	37	40.64	.27	14	39.67	.21	18		
22.18	.36	17	21.46	.23	39	21.06	.37	16	21.65	.32	23		
98.08	.63	18	99.19	.41	31	100.33	.60	15	98.74	.49	19		
53.22	.46	18	53.96	.36	27	53.14	.60	14	53.00	.41	18		
63.92	.55	13	63.71	.48	24	64.00	.66	13	62.81	.65	16		
32.61	.50	23	32.17	.36	24	28.86	.81	13	29.87	.51	15	(30?)	
103.64	1.21	14	104.66	1.50	12	100.50	2.65	5	102.50	1.23	9		
127.26	.76	13	*123.22	1.42	11	122.50	3.36	5	120.06	1.04	9		
32.41	.31	22	31.36	.35	25	31.57	.92	7	31.57	.50	14		
122.62	1.00	18	124.78	.91	22	122.22	1.48	7	122.20	.68	13		
77.29	.51	24	75.48	.32	56	77.60	.57	21	76.62	.55	25	80.7	82.66
73.00	.40	22	*71.50	.34	49	71.97	.50	19	74.87	.55	19		
62.79	.37	24	62.24	.25	54	*63.74	.47	21	64.22	.46	25	65.5	68.22
94.07	.85	21	94.60	.42	49	93.55	.74	19	*96.34	.74	19		
81.87	.58	24	82.59	.27	54	82.02	.40	21	84.13	.51	26	81.2	82.59
67.50	.59	19	68.60	.35	50	68.66	.35	19	69.46	.53	23	67.8	68.80
92.56	.58	18	92.36	.34	29	94.67	.59	18	94.03	.52	15	92.5	91.66
72.50	.59	16	73.57	.58	29	72.87	.45	18	73.13	.65	16	73.4	75.01
106.00	1.25	14	105.25	.95	16	104.00	3.03	6	102.80	1.39	10	104.1	103.80
75.77	.80	15	78.06	.75	16	75.50	2.11	6	77.86	.99	11	76.3	77.82
85.62	.93	17	88.74	.94	17	82.85	1.50	8	86.70	.76	10	86.6	86.77
51.15	.62	17	52.57	.51	27	51.74	.64	17	52.93	.46	14	53.4	51.66
48.50	.53	19	48.96	.56	35	48.62	.62	17	48.94	.65	18	47.9	66.39
83.56	.87	17	33.11	.53	36	81.62	.89	16	83.50	1.31	17		
116.75	1.67	12	117.85	.90	23	116.75	1.67	12	118.81	.84	16		
161.08 cm.		14	165.38 cm.		10	164.86 cm.		3	165.57 cm.		5		165.46
1.30 (from Myc-			1.18			1.50			1.84				
1.30 enaean)			1.20			1.46			1.75				
4.01		21.3	3.87		54.7	4.13		20.5	4.48		26.5		
102.19	1.80	20.1	101.46	1.05	38.3	*107.71	2.26	17.1	108.55	2.70	19.2		
	35			37			26			29			

in Table III deviating from total males. Omit Cephallenia from chronological trends.

added from the racially unknown mountain regions of western and northwest Greece respectively.

Compared with the Mycenaean sample the Early Iron Age vault averages heavy, well-filled, shorter, and more mesocrane, with significantly broader skull base and a high, relatively steep, rounded, and smooth forehead. The face tends toward an hexagonal outline, with broad rhomboid orbits, big cheekbones, a more salient and strong-spined nose, and a large mandible whose more obtuse angles and weak chin suit the strongly orthognathous facial profile. An edge bite hardly accords with this, but goes with worn teeth and a rise in teeth loss and abscesses. In accord with this description the type dominance shifts

T A B L E

Schematic group descriptions, based on metric and morphological deviations between

	NEOLITHIC AND EARLY HELLADIC	MIDDLE HELLADIC-LATE HELLADIC II	MYCENAEAN LATE HELLADIC III	CEPHALLENIA SUBMYCENAEAN
Mean age	34.7 years (27)	39.3 years (23)	40.0 years (41)	40.7 years (30)
Skull vault description	Almost dolichocrane;relatively high, with narrow base	Larger,broader,& rel. lower skull with shorter and broader base	Slightly smaller, skull, narrower, less well filled and lower	Larger, longer, more dolicho & long-based;with rel. broader forehead
Headform: N	24	22	40	25
Ellipsoid	8.33 %	27.27 %	10.00 %	16.00 %
Ovoid	54.17	31.82	37.50	28.00
Pentagonoid	25.00	13.64	45.00	36.00
Rhomboid	4.17	4.55	0	4.00
Sphenoid	4.17	13.64	2.50	8.00
Byrsoid	4.17	9.09	5.00	4.00
Spheroid	0	0	0	4.00
Browridges	Medium - large	Large	Rugged	Medium
Forehead and	Medium	High, wide, and rel. vertical	Low, narrower, and sloping	Low, me erect
Frontal	Bossed	Bossed	Weak contour	Constricted
Parietal	Postcoronal dip; wide-bossed	Flat vertex,and smooth	Bossed; lambdoid flattening	Scaphoid,bossed, lambdoid flat.
Temporal	Slightly flat	Medium	Medium	Slightly flat
Mastoids	Medium	Medium	Medium - large	Medium
Occipital	Slight curve, & small torus	Bulging; medium torus	Intermediate	Medium
Base	High basion	Medium basion	Deep glenoid fossa	Thick tympanic plate
Face description	High,long, and protruding face, with rel. deep and narrow jaw	Lower,broader,& retreating.Upper face constricted. Shallower jaw	Sl.narrower,much wider-& squarer-jowled,with alveolar protrusion.	Low face, with long palate,prognathism,nasal tilt,low orbits.
Face outline	Linear	Hexagonal	Trapezoid	Square
Face profile	Protrusive	Straight	Concave	Prognathous
Orbits	Elliptical: axes horizontal	Rhomboid: axes drooping	Angular :medium.	Rounded; slight tilt of axes
Cheekbones	Compressed	Retreating	Rel. prominent	Compressed
Nasion depr.	Slight	Medium	Medium - deep	Medium
Nose	High and straight with broad nasal bones	Narrow root; Concavo-convex; big nasal spine	Weak. Concave-straight; small nasal spine	Coarse, concave, and projecting.
Palate	High-arched	Very high, and parabolic	Slight alveolar prognathism	Elliptical. Med. alv. prognathism
Mandible	Compressed, and deep-chinned	Weak-chinned	Massive;big chin; everted angles	Compressed
Type of bite	Edge-to-edge	Overbite	Sl. overbite	Overbite
Teeth	Very good, with slight crowding	Good quality	Medium. Absorbed alveolae	Good
Extra-modal observation %s	40.4	43.7	41.7	43.5

Note : no probable errors were calculated for morphological observations because of be considered as only tentative; though mirroring of salient features of its dominant

'om Basic White to an Alpine-Dinaric combination in which Iranian 'aits are individually detectable. A Mediterranean minority persists, nd heterogeneity is less striking than in the Middle Bronze Age. But s in that period, the change from a general "Mediterranean" norm is)o great to explain except by invasion. The hypothesis of a northern, resumably eventually a Balkan or Central European source for the ıvaders seems certain (compare the Alpine, Mixed Alpine, Dinaric, nd Hallstatt Nordic makeup of Balkan Illyrians in Angel, '42 b, table V, columns 3 and 4). And the Dorians and other invading tribal groups ay have learned Greek in some area not far north of Central Greece. ata are inadequate to show how far emigrations at beginning and end

I X

periods, exaggerated to emphasise combined expressions of types' salient features

EARLY IRON AGE SUBMYC.-GEOM.	CLASSIC TO HELLENISTIC	ROMAN AND LATE ROMAN	BYZANTINE AND MEDIEVAL	37 LIVING GREEK MALES
38.3 years (27)	42.6 years (52)	42.1 years (18)	36.5 years (31)	37.0 years when measured
Shorter & wider, with broader base shorter parietal, & wider frontal.	Longer, lower, & more dolicho;sl. longer & narrower base;long parietal,short frontal	Smaller,shorter, & more mesocrane; rel.higher;longer base;short parietal,wide frontal.	Smaller,shorter, narrower, & relatively higher vault	Larger,high, and broader vault
25	50	18	29	
16.00 %	24.00 %	27.78 %	24.14 %	
32.00	28.00	22.22	51.72	
44.00	28.00	16.67	10.34	
4.00	10.00	0	8.90	
0	6.00	0	0	
4.00	2.00	22.22	3.45	
0	2.00	11.11	3.45	
Small	Medium - large	Heavy	Medium	Medium-small
High and erect	Low and sloping	Marked slope	Low, narrow, & medium slope	Comp. high, broad, erect
Bossed	Average	Constricted	Average	Full
Smooth, with flat vertex	Long and smooth	Scaphoid; lambda flat; no bosses	Intermediate	Lambdoid flattening
Full	Medium	Sl. bulging	Medium-full	Sl. bulging
Medium - small	Medium	Large	Medium	
Intermediate	Protuberant. Medium torus	Medium. Large torus	Protuberant. Small torus	Feeble curve
High basion.Elliptical meatus	Deep glenoid fossa	Deep glenoid, & thick tympanic	High basion & deep glenoid	
Midfacially wider. Longer nose. More obtuse jaw angle.	Higher & wider-jowled face with bigger orbits	Relatively wider & lower.Big nose. Shallow chin, & narrower jowls.	Higher & wider-jowled face with less prominent nose	Larger face, with bigger nose
Hexagonal	Rectangular	Invert trapezoid	Slight trapezoid	Square
Retreating	Straight	Convex	Weakly concave	Straight
Rhomboid: medium tilt	Oblong: medium tilt	Rhomboid and drooping	Oblong; tilted	
Large	Medium	Large	Small	Strong-med.
Small	Medium	Medium - deep	Medium	Medium
High-bridged, with strong nasal spine	Wavy-profiled. Subnasal grooves.	Big & salient, with "classic profile"	Average. Straight profile	Medium-high; wide bridge. wavy-strght.
Small U shape	Parabolic	Low and parabolic	Parabolic. Slight alv. prognathism	Orthognathic
Retreating chin	Slightly everted angles	Strong & bilateral chin	Pointed chin	Very strong jowls & chin
Edge-to-edge	Slight overbite	Overbite	Overbite	More over
Fair. More wear, loss,abscesses, & absorption 43.7	Very good, with less wear 42.3	V.good.Less wear; M_3 suppressed, & slight crowding 42.9	Medium quality, more loss, and slight crowding 43.8	Unworn.More loss, caries Poorer.

the exiguous samples available f.. most periods. The descriptions must therefore types by any given period group may be judged of interest in the present study.

of the period may have affected Bronze Age survivals, in spite o Mediterranean increase in Cyprus at this time (Fürst, '33).

The relatively homogeneous Classical Greek series is significantl more dolichocrane and has a large, relatively smooth braincase wit long parietals and skull base, well-curved occiput, and relatively shor wide, and sloping forehead with clearcut browridges. Rectangula norma facialis goes with oblong orbits, and widely separated goni The facial profile is not over-orthognathous, and combines an averag concavoconvex nose plus weak spine and slight subnasal grooving an no "Classic Greek profile" with a mouth tendency toward an overbi accompanied by better and less worn teeth than in the Early Iron Ag and an added trend toward suppression of third molars. This skelet norm fits the artistic ideal of the period well except for the nose wher the ideal's excess root height may represent a stretching of skin u supported by bone. Figure 4 illustrates the Classical Greek blend as less Alpine version of the total series, according precisely with dom nance of all three long-headed types and especially with the Nordi Iranian's rise almost to its Middle Bronze Age frequency. A defini Mixed Alpine minority replaces the Alpine-Dinaric element of the pr ceding period, indicating a process of mixture of Early Iron Age i vaders with Bronze Age leftovers. In this process recombination o Nordic-Iranian strains contained in both Dinaric-Mediterranean i vaders and Basic White Mycenaeans contributes to the Classical exce of Nordic-Iranians, many of whom individually show Mediterranea Basic White, or Alpine minor traits. Existence in Classical and Helle istic times of a strong Nordic-Iranian element among Anatolian Greek (compare plates in Schumacher, '26, and table 7 in Angel, '42 b) a well as Basic Whites and Mixed Alpines suggests that influx from th source is plausible at the start of the period. Metics and slaves ma have had some effect in reinforcing the generally long-headed trend o the period, though a minor one.

The average Roman period braincase is more mesocrane and short and perhaps higher and longer-based than the Classical sample. Th vault is smooth and often byrsoid in norma verticalis, scaphoid, wit lambdoid flattening, strong nuchal muscle markings, big mastoids, an sloping forehead with big browridges. The broad and subnasally lo face has big cheekbones but rhomboid orbits, and combines shallo chin with average jowls to emphasize an inverted trapezoid more tha hexagonal facial outline. The salience and curve of the large nose co trast with the very orthognathous face and tend to continue the line o the forehead in a form of "Classic Greek profile". The chin is prom

ıent, an urban degree of overbite correlates with lessened teeth wear, slightly more crowding, and further suppression and cusp reduction of hird molars. Dinaric-Mediterranean and also Alpine increases ex- plain these changes, with Alpinoid domination tempered by persistence of an Iranian strain linked closely with the Dinaric-Mediterranean. A ise in variability is partly explained by lack of smooth blending and consequent average association of Dinaric-Mediterranean braincase with Dinaric-Iranian nose set unexpectedly in an Alpine face. This argely parallels the changes brought by the Dorians, and suggests in- iltrations from the mountain plateaux of southern Illyria (Schwidetzky, 40, and Weisbach, 1897 and '07, summarized in Angel, '42 b, table 3), ince a true Dinaric compromise between Hallstatt Nordic, Mediter- anean, and older Alpine strains appears to have been reaching domi- nance here at about the time of Roman penetration (compare also indi- idual Carniola skulls of this date in Vram, '03). But southeastern ources cannot be overlooked entirely (compare Ephesian Dinarics in Schumacher, '26). And selection resulting from population reduction nust have been an important factor.

The Byzantine series has a small vault (significantly smaller than he Classical period) relatively higher and slightly narrower than the Roman period vault, less muscular, and marked by prominent occiput nd less sloping forehead. The face is fuller-jowled and slightly nar- ower-proportioned, with smaller cheekbones and tilted oblong orbits. The nose is smaller and much less salient: too weak to dominate slightly rominent mouth and pointed chin. Slight overbite and teeth crowding ontinue, and teeth loss and caries increase. This stereotype is ade- uately explained by juxtaposition of gracile Mediterranean and Alpine ominances, with enough Nordic-Iranian influence to deepen and square p the lower face. Lack of smooth blending of contrasting types paral- ls the Roman as opposed to the Classical period, and is likewise re- ected in high average Byzantine variability. Although it seems very robable that Alpine (-Dinaric) and Nordic-Iranian minorities were rought into Byzantine Greece by northern invasions such as those f Slav-speakers and Avar camp-followers, the Mediterranean increase oints to maritime immigration, except for individuals of Pontic Medi- erranean type (Coon, '39, p. 617) who may have been among invading ordic Slavs (Slavic urnfields sample in Debetz, '30).

No type frequency predictions have been worked out for the small eries of living Greeks from around the isthmian region, since esti- ıated skull measurements like those of the next to last column of table

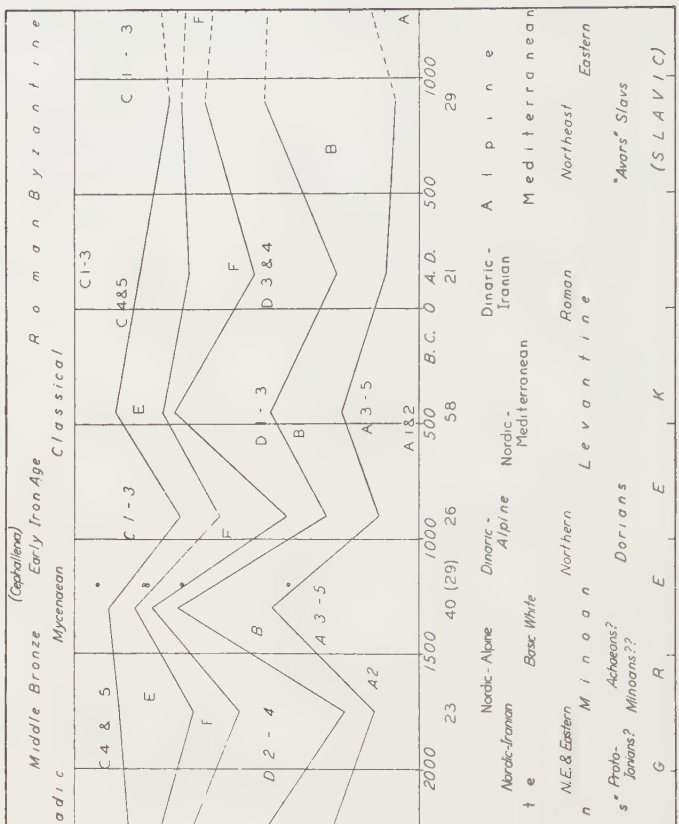

Fig. 13. Racial history of Greece from Neolithic to Byzantine times in terms of morphological types. Relative frequency of each type at any given time is shown by the relative widths of the six bands marked with letters symbolising the types: race is shown vertically plotted against time shown horizontally. Each letter marks a phase of importance or relative increase of a type, reflecting results of invasion, selection, or mixture. The earliest period is dominated by rugged and gracile Mediterraneans, plus definite Alpine elements. Middle Bronze Age's large deviation and exceedingly high variability show effective invasion of Nordic-Iranians and Alpines (more "Eastern" than "European") combining to produce Mixed Alpine hybrids and hence a relatively even balance of contrasting types. The Mycenaean period shows complementary reaction toward Basic White dominance through absorption of invaders and possibly through southeastern reinforcement, with resulting homogeneous racial blend. This cycle repeats in Submycenaean to Classical times, with Alpine-Dinaric (Nordic) invaders and subsequent reaction in a Mediterranean-Nordic (Mixed Alpine) direction. A third repetition of the cycle breaks down in gracile Mediterranean vs. Alpine contrast following Alpine domination of a Dinaric-Iranian complex in Roman occupation times. This chart inevitably exaggerates racial changes and fluctuations and obscures continuity and major trends. Table 6 shows statistical certainty of the

can never be certain, although they allow comparisons.[24] The aver-
ge is a well-filled and fairly high-headed brachycephaly, with high and
road forehead and nonprotuberant occiput. The face is broad and not
xcessively high, somewhat square in outline, and marked by broad
owls, strong chin and cheekbones, long, thick, and straight (-convex)
ose, and poor teeth with a developed overbite. Alpine dominance is
nked with a pervasive though limited Dinaric trend and contrasts with
strong Basic White minority. Gracile Mediterraneans are common,
nd Nordic-Iranians not absent though rarer than in north Greece.[25]
he modern Greek series resembles the Roman more than the Byzantine
ample and continues Roman period trends away from the Classical
eriod norm. This shows the racial continuity between ancient and
odern Greeks, though the modern sample differs considerably from
ncient Greeks taken as a whole.

Next to their heterogeneity, this unbroken racial continuity of the
reeks is the most important conclusion from the outline of their racial
istory. Continuity does not mean stasis. And several long-term trends
re perceptible in tables 6, 7, 8 and 9 in addition to the period by period
acial fluctuations.

The major racial trend is a gradual shift from a virtually long-
eaded, "Mediterranean" mode toward an Alpine norm, with incipient
inaric features subtly added [26] as suggested in figure 13. Inclusion of
lpines with southeastern as well as with northern immigrations into
reece may well be one reason for this trend, which derives inextricably
om alternation of two contrasting racial complexes. One is a dolicho-
orph and mainly Mediterranean blend, generally unified, and charac-
ristic of periods of cultural unity such as the Mycenaean and Classical,
ith weaker effect in the Early Bronze Age. The other is marked by
lpines either mixed with or next to Nordic-Iranians, heterogeneous,
nd occurring in phases of invasions and confusion such as the Middle
ronze Age, Early Iron Age, and Roman period. The Byzantine sample

[24] Estimates are based on the skin thickness and bone shrinkage allowances given by Krog-
n, '39, assuming that caliper pressure is equal to his tissue dehydration allowance.

[25] The sample has the following geographic derivation: Doris and Phocis (5); Boeotia, C.
boea, Megaris (5); Athens (5); Corinth and Argolis (5); rest of Peloponnese (11);
ian islands (6). The sample differs surprisingly little from that presented by Coon ('39,
606–607), drawn from American Greeks, but is less Dinaric (or Armenoid) than Weis-
h's (1881) non-ancient Greeks almost wholly from Turkish territory. The present sample
bably underestimates stature and head length.

[26] Supported by specific trends: cranial index rise; better filling of braincase; rise in vault
ght after Early Iron Age; shorter, wider, flatter frontal; broader, shallower-chinned, more
hognathous face, with wider and bigger nose and broader jowls.

combines both complexes, perhaps because of too great a time span.[27] These fluctuations have been linked with sea-borne immigrations fro south and southeast and with invasions from north, northeast, or ea respectively, and with the absorption of such intruders by the e tablished population of Greece. This forms a regular cycle of raci change so timed that the fluctuations describe an irregularly spiral pat around the central racial trend.

Two less sweeping trends are interesting because the type predi tions in table 7 show them incompletely or not at all, and they are ther fore emphasized by their departure from prediction. The first of thes is a steady increase in nose size from Middle Bronze down to Roma times, and then down to the present day. Roman period nose heig significantly exceeds Middle Bronze or Mycenaean values, and no breadth almost does so. This is shown weakly in the predictions fro Mycenaean times onward, and must be some sort of Dinaric-Irania genetic recombination.

The second trend is a rather sharp rise in bigonial breadth startin earlier than the slight Alpine increase in other face breadths and co tinuing less markedly down to modern times. This shows a steady d parture from predicted values. It springs apparently from Nordi Iranian and Basic White recombination of linked genes, with seconda association with Alpine features.

The major non-racial trend is a general increase in stature, especial from prehistoric into historic times, utterly unpredicted by morph logical type changes, and supported by a less clearcut increase in hea size, involving horizontal circumference and skull base length especiall up to Roman times, with a definite drop in the Byzantine period. B zantine stature may be overestimated. And it is virtually certain th this size increase is environmentally caused by a steady improveme in diet and hygiene from prehistoric to Classical and Roman time followed by a medieval lapse.[28]

The dentition of ancient Greeks shows many interesting chron logical fluctuations, with one major trend worth stressing. This is

[27] Fluctuations supported by rise in cranial index in Alpine-influenced phases, with full vault, lower and more hexagonal face, lower orbits, and probably greater nasal saliency. C posite in other periods. Selection and emigration are probably as important factors as immig tion in causing these fluctuations which the type frequencies tend to exaggerate.

[28] This is demonstrable lengthily from food remains found by archeologists, by various in cations of improvement in agricultural methods, and from historical records. After an in dence of over 20% in E.H. times, osteoporosis of parietals or orbital roofs disappears un Roman-Medieval times. Life expectancy increases up to Classical (-Roman) times, with su sequent drop. The same is true of population size.

orphological complex involving more overbites, slightly deeper enoid fossae, probably more crowded teeth and more alveolar ab-rption, degeneration of the third molar, and shallower and slightly ore prominent chins. It develops from prehistoric to historic times, aching full bloom in the Roman period and again among living reeks. This masticatory degeneration clearly is linked with use of ore "civilized" food, with other causes less obvious, though a con-ction with increasing Alpine influence seems unlikely.

From a broad anthropological standpoint fluctuations in variability e the most interesting ones. Mycenaean and Classical periods of mmercial success and high cultural achievement both show a "nor-al", relatively low, variability with dominance by a single "Mediter-nean" racial amalgam: a smooth pan-mixia of potentially contrast-g genetic tendencies. These periods follow and precede historic ases of invasions, isolation, and cultural confusion marked by high riability with an even balance between contrasting types or a struggle r dominance between two divergent type complexes. Thus a pattern vigorous outbreeding and rapid racial fusion marks the transition om Middle Bronze Age to Mycenaean and less extremely from Early on Age to Classical period: formation of a successful culture is ked with formation of a smooth racial blend. The relatively slight e in Early Iron Age variability [29] is a function of the relatively short ration of the Dorian invasions with less complete cultural depression an in other periods of turmoil. Hence the major trend in variability a significant drop from the elevated Middle Bronze Age level fol-ved by a stress on racial fusion into the Classical period, with subse-ent rise in variability and in racial heterogeneity. This trend makes arer the association of reduced variability and racial fusion with h things as population increase and free intercommunication be-een easily isolated harbors and valleys, as well as general high el of culture.[30]

Thus although the use of types allows a more dynamic understanding n otherwise possible of the connection of changes in variability with e mixture, it does not show the ultimate causes of racial fusion nor precise relation of this process to cultural achievement. These ngs obviously would be of great psychological, social, and historical

Raised variability shows in the extra-modal observation percentages in table 9, and site ps look very heterogeneous early in the period, though metric variability is not high. In-ion of Cephallenians would raise variability sharply.

An interesting reduction in speed of racial change, as shown in tables 6 and 8 by the degree ifference between periods in racial types and in measurements, accompanies both population ease and cultural rise.

interest. Without a more detailed sociological analysis it is impossib to draw far-reaching conclusions along these lines. But race mixtu is a genetically stimulating process (Ashley Montagu, '42, pp. 98–100 and the facts arrayed by typological analysis of Greek racial histo support the historical principle that great peoples are as intense mixed biologically as culturally.[31]

GENETIC REALITY OF TYPES

Any attempt to generalize the characteristics of a population mu be a compromise between two abstract realities: (1) every individu in a group living together as a social or socio-political unit, and (the distribution and linkage-combinations of genes in this breeding un One arbitrary compromise is the synthesis from arithmetic means an average individual with variability constants to show the spread the rest. The second compromise, stressed here, is the equally arbitra analysis of relatively discontinuous phaenotype groups, in the ho that these result from correlation between genetic characters whi arithmetic means overlook. Even though the inevitable artificiality such types prevents close accord with flexibly shifting genetic linka groups, this analytic method is a closer approach than the synthet average to the reality of a society, since it takes some account of t differences between individuals.

It is widely differing individuals who originate or maintain a culture. Neither imaginary average individuals nor varying gene fr quencies can do this. Changes in quality or level of culture and con tioning of the environment of later generations occur as the product interactions of individuals, greatly affected by the differences betwe them, rather than as the sum of solitary thoughts and acts of each o This greatly enhances the value of the types' illumination of individu divergences.

The arguments and facts already given are enough to show that t types do approximate at least one set of genetic linkage group su divisions of the population.

Three drawbacks to use of types are equally clear. First, the typ cannot make allowance for formation of new genetic combinations, shown by failure of type predictions to forecast trends in Greek jo breadth and nose size. Second, the types are further subdivisible bo

[31] This essay is too compressed to include the precise racial makeup and origins of each the specific peoples included in the Greek ethnic group. The reader can deduce for hims from the text and from figure 13 such probabilities as that the Dorians were of mainly Alp and Dinaric composition, with a Nordic strain suggested in many individual Dinaric sku and that the bulks of them may have come down by slow degrees from what is now Bosnia.

because they are made up of more homogeneous but statistically unuseable subgroups, and because they show irregularly high variabilities in isolated measurements, more often in face than vault. Third, the types cannot allow for environmentally determined changes, such as those caused by nutrition.

The types are too rigid and somewhat too composite to reflect precisely all the subtleties of genetic fluctuations in the Greek population. But they do have some genetic reality, and in clarifying the process of new genetic additions during invasions with subsequent mixture and recombinations they give a much more brilliant picture than averages alone. And I conclude that use of types even unsupported by elaborate statistical testing, as in Coon, '39, is a completely valid process as long as the artificial rigidity of such types is recognized.

SUMMARY

1. Ancient Greeks as a whole are unusually heterogeneous.

2. Their high variability is 7% above normal, and expresses the contrast between six arbitrary morphological types: Basic White, an ill-filled, rugged, long-headed, coarse-faced version of Atlanto-Mediterranean; gracile, dolichocrane, pentagonoid Classic Mediterranean, with narrowed triangular face; muscular, well-filled, long, hawk-nosed, rectangular-faced Nordic-Iranian; mesocrane and high Dinaric-Mediterranean hybrid, with long nose in long hexagonal face; intermediate Mixed Alpine, with puffed-out mesocrane vault, big forehead, and squat face; and round-headed, blunt-faced Alpine. These types are validated by close comparison with non-Greek groups, by their low variability, and by their generally successful predictions of period groups.

3. Greek racial history shows an alternation of an overwhelmingly "Mediterranean" complex reflecting southeastern maritime infiltrations, and a more balanced Alpine-influenced combination of all types reflecting northern invasions. The former is typical of Mycenaean and Classical periods and occurs in the third millennium B.C. The latter dominates Middle Bronze, Early Iron, and Roman periods, with compromise effect in Byzantine. Within these fluctuations of opposing tendencies the major racial trend is in an Alpine direction, with minor Dinaric specialties.

4. Racial continuity in Greece is striking.

5. Some trends, such as increase in nose size, reflect genetic recombinations, others, such as gross size increase, respond to environmental changes.

6. Reduction in variability in Mycenaean and Classical periods of historic achievement is associated with outbreeding, or racial fusion, linked in turn with population increase, slowing of racial change, and ease of communication. I conclude that the Greeks, like other outstanding peoples, benefited from their mongrel origins.

7. Racial types as used in this study have a considerable genetic reality, shedding light also on genetic changes which they are too artificial to express, and giving a much more dynamic picture of racial history than is available from arithmetic means.

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REVIEW

ANTHROPOLOGISCHE UNTERSUCHUNGEN AUF BALI UND LOMBOK. By J. P. Kleiweg de Zwaan. Medeelingen van de Afdeeling Volkenkunde van het Koloniaal Instituut, Leiden, extra ser. no. 4, 1942, 322 pp. (374 photographs by Mrs. Kleiweg de Zwaan.)

We have to thank Prof. de Zwaan for another important study on the somaology of the Netherlands East Indies. According to press accounts he spent months, beginning in September, 1938, in the islands of Bali and Lombok. n Bali he worked in the prisons of Den (= Southern) Passar (= Market), Karangasam and Singardaja; the tourist resort of Tenganan, in the artistic enter of Ubud; and in the mountain resort of Kintamani; he also studied roups of Bratan Sembiran in the north.

Prof. de Zwaan was interested above all in east Lombok, because here the Balinese influence is less pronounced. [1] In this island he worked in the prison of relong; and later in Sewela, where there were people from Sapit and the mounain villages of Sembalun.

The results of this study form a voluminous book weighing over 4 lbs. t is rich in detail. Besides the usual anthropometric observations there are ncluded studies by Mrs. de Zwaan on dermatoglyphics and taste sensitivity. Remembering perhaps the words of Prof. Joachim Pires de Lima: "Theories rane but facts persist," Prof. de Zwaan's publication is chiefly of a descriptive ature and almost devoid of any attempt at racial deduction and synthesis. A etter title would have been "Anthropographic Studies."

The basis for anthropographic studies in this region should be the congeneric omogeneous group of the smallest settlement, the padoekoean (hamlet, from oekoe—to sit down), where the people live and intermarry in the same enironment. These homogeneous communities form the cornerstone of the desa, ne administrative unit. Because of the pronounced endogamy in these settlents, there are often great somatological differences between the padoekoeans of ne same desa. This is shown, for instance, by the stature and cephalic index hich I obtained for the Desa Pengoenboelanadi in the central limestone mounins of Java (Goenoeng Kenoeng), made famous by the Trinil and Ngandoeng ossils. If we were to combine the padoekoeans Gradjan and Doekoepengaran we ould be convinced that they were a tall population with medium long heads stature 164,3; C.I. 81.7). If we were to combine the padoekoeans Delé and oemanding, we should have a totally different result (stature 160.1; C.I. 83.8). ombining the padoekoeans Soemanding and Tjoelig we should find even an alost small, brachycephalic people (stature 158.5; C.I. 84.5). Thus the manner combining the basic communities often influences the results and makes them ore questionable than if the numbers were too small to allow the statistical onstants to be calculated. Consequently, it is just as desirable to have averages or the separate padoekoeans as it is to have individual measurements.

[1] However, in the remote parts of west Lombok live the interesting Bodha's, who are almost nknown and even at present belong partly to the food collectors.

In the case of Bali, however, Prof. de Zwaan not only has failed to give the data of the basic homogeneous populations, but also he has combined seven primary populations into one meaningless group. Furthermore, he has united three such combinations into a still more vague group called "Bali Aga" or "Bali Moula." He has assembled into another combination, which he designates "other Balinese," individuals from all over Bali, including convicts without any congeneric link — the result of the locally unnecessary custom of studying prisoners. The first mentioned group is representative of the old Indonesian wood civilization; the latter groups of the Indian stone culture and "sacred water religion." We know hardly anything about the origin of the second group it might have come equally well from Djembrana in the west, or Karangasam in the east, or the totally different north. Of the first combination we know at least that it includes inhabitants of the strongly endogamic Tenganan desa in the tropical southern plains, of Kintamani on the crater wall of the Batoer volcano in the high subtropics, and of the endogamic Sembiran in the hot limestone hills near the north coast. Thus Prof. de Zwaan has disregarded the law of geographic proximity which was brought out in my studies in Nousantara, Madagascar and Africa;[2] namely, that all populations living in the same biocirc[3] tend to be more closely related than those separated by great distances.

Prof. de Zwaan profited from his sojourn in Bali and from the advice of our mutual host, Dr. Soudjono, who helped me greatly during my visits in 1931 and 1932 and who knows the Sasaks rather well, and hence the material relative to Lombok is more locally collected and much better classified. But here, too, Prof. de Zwaan has combined basic connubial communities with the idea of getting lower mean errors from the larger samples.

Brief mention should be made also of at least two questionable conclusions of a different nature: The first relates to the cephalic index; the second to skin color.

Prof. de Zwaan is of the opinion that mountain populations should have a higher cephalic index: "Man im allgemeinen in den Bergen einen höheren Kopfindex erwarten sollte" (p. 141.) Accordingly, since the Kintamani group has a cephalic index of 81.06 ± 0.200, which is just above the arbitrary limits of mesocephaly according to Rudolph Martin (but not above the limits set by Broca, Deniker, Montandon, and others), Prof. de Zwaan declares the whole population to be "brachycephalic." Judging from my own observations, if he had studied the padoekoeans of Goenoeng Batoer and Goenoeng Rindjani, he would certainly have found more mesocephaly.[4] This phenomenon is seldom found on either island, especially Lombok, which is strongly influenced by the brachycephalic Soembawa. Nevertheless it is of great phylogenetic and racial diagnosis

[2] Geoserology of Nousantara. Congreso Internacional Hispano-Luso-Americano de Anatomía. Santiago de Compostela, 1943. See also: Geobiologic assimilation on the Sunda Arch. Coimbra, 1944.

[3] A primary natural geographic area. The biocires of the natural geographic area formed by Bali, Lombok and Soembawa form a bioregion.

[4] That the Lombok mountaineers of Sembalun should have a higher cephalic index, higher head and higher height: length index than those of the plains population (p. 298) is unlikely. Also, Prof. de Zwann does not mention the existence of a mesocephalic population in Java which I reported in 1929.

tic value, indicating the more primitive layer of "Orang goenoeng" and the more progressive brachycephalic "Orang pantai" evolving therefrom.

Using the color scale of Bruno Schultz, Prof. de Zwaan has come to the conclusion, contrary to Rudolf Martin's opinion, that the color of the unexposed skin of the chest is darker than that of the abdomen. Since my own findings, based on the Luschan scale (this becomes less deficient when the skin is moistened), indicate an increase in pigmentation in the caudal direction and thus accord with Martin's, it is to be doubted that Prof. de Zwaan fully excluded the effects of the sun's rays.

Geobiological research is very difficult and it takes years of living on the spot before a thorough knowledge of a population and adequate technical experience are acquired. I myself began almost without experience and have had many failures, but at least I now know how it should be done. Even the most intensive statistical work cannot make good the mistakes made by research workers who have lost their ability through lack of practice or unfamiliarity with the environmental setting. For this reason I favor field work being done by one specialist and laboratory work, which is of a totally different nature, by another.

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